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U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY—BULLETIN No. 106.
L. O. HOWARD, Entomologist and Chief of Bureau.

THE LIFE HISTORY AND BIONOMICS OF SOME NORTH AMERICAN TICKS.

BY

W. A. HOOKER, F. C. BISHOPP, AND H. P. WOOD.

UNDER THE DIRECTION OF

W. D. HUNTER.

ISSUED SEPTEMBER 7, 1912.

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BUREAU OF ENTOMOLOGY.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Entomology,
Washington, D. C., November 29, 1911.

Sir: I have the honor to transmit herewith a manuscript entitled "The Life History and Bionomics of Some North American Ticks," prepared by Messrs. W. A. Hooker, F. C. Bishopp, and H. P. Wood, under the direction of Mr. W. D. Hunter, of this bureau. Ticks are of considerable importance in the United States in two respects. Two species are the sole agents in the transmission of certain important diseases. One of these diseases is the well-known splenetic fever of cattle and the other the Rocky Mountain spotted fever of human beings. The information contained in this manuscript will be of immediate value in connection with the eradication of the cattle tick and also of the form which transmits spotted fever. The remaining species treated in this manuscript are now of importance principally as parasites of domestic animals. In many localities they present serious problems to the farmer. Moreover, there is a possibility that some of the species not known at present to be carriers of diseases will eventually be found to be of importance in connection with disease transmission. For these reasons full information regarding the life history of the various species is in demand.

The work upon which this bulletin is based has extended from 1907 to the present time. The manuscript is intended to be a compendium of information regarding ticks which will remain of direct value for many years and make unnecessary the publication of special bulletins on some of the species treated.

I recommend that this manuscript be published as Bulletin No. 106 of the Bureau of Entomology.

Respectfully,
L. O. Howard,
Entomologist and Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

	Page.
Introduction	13
Concerning ticks in general	14
Systematic position and classification	14
Collecting, preserving, and mounting	17
Economic importance	18
History of the biological study of ticks	20
Geographical distribution	21
General life history	24
Habits	25
Multiplication	32
Locomotion and dissemination	33
Seasonal history	34
Methods employed in studies of ticks	35
Natural control	41
Artificial control	44
Development of the Argasidæ	45
Genus Argas	45
The fowl tick, *Argas miniatus* Koch	46
Descriptive	46
Host relationship	47
Geographical distribution	47
Life history	48
Life cycle	59
Economic importance	60
Natural control	60
Artificial control	61
Genus Ornithodoros	61
The spinose ear tick, *Ornithodoros megnini* (Dugès)	61
Descriptive	62
Host relationship	62
Geographical distribution	62
Life history	64
Life cycle	68
Economic importance	68
Natural control	69
Artificial control	69
Development of the Ixodidæ	69
Genus Ixodes	76
The black-legged tick, *Ixodes scapularis* Say	76
Descriptive	76
Host relationship	77
Geographical distribution	77
Life history	77
Life cycle	81
Economic importance	81
Natural control	81
Artificial control	81

Development of the Ixodidæ—Continued. Page.
Genus Ixodes—Continued.
The rotund tick, *Ixodes kingi* Bishopp........ 82
Descriptive........ 82
Host relationship........ 82
Geographical distribution........ 83
Life history........ 83
Life cycle........ 88
Economic importance........ 88
Natural control........ 88
Genus Hæmaphysalis........ 89
The rabbit tick, *Hæmaphysalis leporis-palustris* Packard........ 89
Descriptive........ 89
Host relationship........ 90
Geographical distribution........ 90
Life history........ 90
Life cycle........ 95
Economic importance........ 96
Natural control........ 96
The bird tick, *Hæmaphysalis chordeilis* Packard........ 97
Descriptive........ 97
Host relationship........ 97
Geographical distribution........ 98
Life history........ 98
Life cycle........ 101
Economic importance........ 101
Natural control........ 102
Artificial control........ 102
Genus Rhipicephalus........ 102
The brown dog tick, *Rhipicephalus sanguineus* (Latreille) (*texanus* Banks)........ 102
Descriptive........ 103
Host relationship........ 103
Geographical distribution........ 104
Life history........ 105
Life cycle........ 110
Economic importance........ 110
Natural control........ 110
Artificial control........ 111
Genus Margaropus........ 111
The North American cattle tick, *Margaropus annulatus* (Say)........ 111
Descriptive........ 111
Host relationship........ 112
Geographical distribution........ 112
Life history........ 112
Life cycle........ 116
Economic importance, natural control, and artificial control........ 117
The Australian cattle tick, *Margaropus annulatus australis* (Fuller)........ 117
Descriptive........ 117
Host relationship........ 117
Geographical distribution........ 118
Life history........ 118
Life cycle........ 122
Economic importance........ 122
Natural control........ 122
Artificial control........ 123

Development of the Ixodiaæ—Continued.

Page.
Genus Amblyomma 123
The gopher-tortoise tick, *Amblyomma tuberculatum* Marx 123
Descriptive 123
Host relationship 124
Geographical distribution 124
Life history 125
Life cycle 129
Economic importance 130
Natural control 130
The iguana tick, *Amblyomma dissimile* Koch 130
Descriptive 130
Host relationship 131
Geographical distribution 131
Life history 131
Life cycle 135
Economic importance 135
Natural control 135
The Gulf Coast tick, *Amblyomma maculatum* Koch 135
Descriptive 135
Host relationship 136
Geographical distribution 136
Life history 137
Life cycle 141
Economic importance 141
Natural control 141
Artificial control 142
The lone star tick, *Amblyomma americanum* (Linnæus) 142
Descriptive 142
Host relationship 142
Geographical distribution 143
Life history 144
Life cycle 150
Economic importance 150
Natural control 151
Artificial control 151
The cayenne tick, *Amblyomma cajennense* (Fabricius) 151
Descriptive 151
Host relationship 152
Geographical distribution 152
Life history 153
Life cycle 157
Economic importance 157
Natural control 158
Artificial control 158
Genus Dermacentor 158
The rabbit Dermacentor, *Dermacentor parumapertus marginatus* Banks. 159
Descriptive 159
Host relationship 159
Geographical distribution 160
Life history 161
Life cycle 164
Economic importance 165
Natural control 165

Development of the Ixodidæ—Continued.
Genus Dermacentor—Continued.

Page.
The Rocky Mountain spotted-fever tick, *Dermacentor venustus* Banks. 165
  Descriptive 165
  Host relationship 166
  Geographical distribution 168
  Life history 168
  Life cycle 179
  Economic importance 180
  Natural control 180
  Artificial control 180
The Pacific Coast tick, *Dermacentor occidentalis* Neumann 181
  Descriptive 181
  Host relationship 181
  Geographical distribution 182
  Life history 182
  Life cycle 189
  Economic importance 189
  Natural control 190
  Artificial control 190
The American dog tick, *Dermacentor variabilis* (Say) 190
  Descriptive 190
  Host relationship 191
  Geographical distribution 191
  Life history 191
  Life cycle 196
  Economic importance 197
  Natural control 197
  Artificial control 197
The tropical horse tick, *Dermacentor nitens* Neumann 197
  Descriptive 197
  Host relationship 198
  Geographical distribution 198
  Life history 199
  Life cycle 203
  Economic importance 203
  Natural control 204
  Artificial control 204
Bibliographical references 205
Index 215

ILLUSTRATIONS.

PLATES.

Page.

PLATE I. Apparatus and contrivances used in life-history studies of ticks. Fig. 1.—Rearing cage. Fig. 2.—Bell jar containing attachment cylinder and animal. Fig. 3.—Outdoor attachment and engorgement box. Fig. 4.—Dropping cage. Fig. 5.—Bull with harness. Fig. 6.—Dog with collar.. 40

II. Apparatus used in life-history studies of ticks. Fig. 1.—Thermograph and apparatus for weather records. Fig. 2.—Pans with glass tubes and pill boxes, in and on moist sand 40

III. The fowl tick, *Argas miniatus:* Fig. 1.—Unengorged larva. Fig. 2.—Unengorged nymph after first molt. Fig. 3.—Unengorged nymph after second molt. Fig. 4.—Engorged nymph after second molt. Fig. 5.—Engorged female, dorsal view. Fig. 6.—Unengorged male, dorsal view. Fig. 7.—Unengorged male, ventral view. Fig. 8.—Engorged female, ventral view......................... 48

IV. The spinose ear tick, *Ornithodoros megnini:* Fig. 1.—Unengorged larva. Fig. 2.—Slightly engorged nymph, dorsal view. Fig. 3.—Slightly engorged nymph, ventral view. Fig. 4.—Engorged nymph, dorsal view. Fig. 5.—Engorged nymph, ventral view. Fig. 6.—Engorged female, dorsal view. Fig. 7.—Male, dorsal view. Fig. 8.—Female from which all eggs have been deposited, ventral view. Fig. 9.—Male, ventral view 64

V. The black-legged tick, *Ixodes scapularis:* Fig. 1.—Unengorged larva. Fig. 2.—Male, dorsal view. Fig. 3.—Male, ventral view. Fig. 4.—Unengorged nymph. Fig. 5.—Partly engorged female, dorsal view. Fig. 6.—Partly engorged female, ventral view. Fig. 7.—Fully engorged female, dorsal view. Fig. 8.—Fully engorged female, ventral view 76

VI. The rotund tick, *Ixodes kingi:* Fig. 1.—Unengorged larva. Fig. 2.—Engorged nymph, dorsal view. Fig. 3.—Engorged nymph, ventral view. Fig. 4.—Male, dorsal view. Fig. 5.—Male, ventral view. Fig. 6.—Unengorged female, dorsal view. Fig. 7.—Unengorged female, ventral view. Fig. 8.—Partially engorged female, dorsal view. Fig. 9.—Partially engorged female, ventral view. The brown dog tick, *Rhipicephalus sanguineus:* Fig. 10.—Unengorged larva. Fig. 11.—Unengorged larva. Fig. 12.—Unengorged nymph. Fig. 13.—Unengorged female, dorsal view. Fig. 14.—Male, dorsal view. Fig. 15.—Partially "deposited-out" female, dorsal view. Fig. 16.—Unengorged female, ventral view. Fig. 17.—Male, ventral view... 84

VII. The rabbit tick, *Hæmaphysalis leporis-palustris:* Fig. 1.—Unengorged larva. Fig. 2.—Unengorged nymph. Fig. 3.—Engorged nymph. Fig. 4.—Engorged female. Fig. 5.—Partially engorged female (balsam mount). Fig. 6.—Male (balsam mount). The bird tick, *Hæmaphysalis chordeilis:* Fig. 7.—Male, dorsal view. Fig. 8.—Male, ventral view. Fig. 9.—Engorged nymph, dorsal view. Fig. 10.—Engorged nymph, ventral view................... 96

Page.

PLATE VIII. The North American cattle tick, *Margaropus annulatus:* Fig. 1.—"Deposited-out" female with eggs. Fig. 2.—Unengorged larva. Fig. 3.—Engorged nymph, dorsal view. Fig. 4.—Engorged nymph, ventral view. Fig. 5.—Unengorged nymph (balsam mount). Fig. 6.—Fully engorged female, dorsal view. Fig. 7.—Male, ventral view. Fig. 8.—Male, dorsal view. Fig. 9.—Unengorged female, dorsal view. Fig. 10.—Unengorged female, ventral view. Fig. 11.—Fully engorged female, ventral view.. 112

IX. The gopher-tortoise tick, *Amblyomma tuberculatum:* Fig. 1.—Unengorged larva. Fig. 2.—Unengorged nymph. Fig. 3.—Engorged nymph. Fig. 4.—Engorged female, dorsal view. Fig. 5.—Females engorging on tortoise's feet. Fig. 6.—Male, dorsal view. Fig. 7.—Unengorged female, dorsal view. Fig. 8.—Engorged female, ventral view 124

X. The iguana tick, *Amblyomma dissimile:* Fig. 1.—Unengorged larva. Fig. 2.—Unengorged nymph (balsam mount). Fig. 3.—Male, dorsal view. Fig. 4.—Unengorged female, dorsal view. Fig. 5.—Fully engorged female (alive). The Gulf Coast tick, *Amblyomma maculatum:* Fig. 6.—Unengorged larva. Fig. 7.—Unengorged nymph (balsam mount). Fig. 8.—Male, dorsal view. Fig. 9.—Unengorged female, dorsal view. Fig. 10.—Engorged female, dorsal view.............................. 132

XI. The lone star tick, *Amblyomma americanum:* Fig. 1.—Unengorged larva. Fig. 2.—Unengorged female, dorsal view. Fig. 3.—Male (balsam mount). Fig. 4.—Unengorged nymph (balsam mount). Fig. 5.—Male, dorsal view. Fig. 6.—Engorged female, frontal view. Fig. 7.—Male, ventral view. Fig. 8.—Unengorged female, dorsal view. Fig. 9.—Unengorged female, ventral view. Fig. 10.—Fully engorged female, dorsal view.. 144

XII. The Cayenne tick, *Amblyomma cajennense:* Fig. 1.—Unengorged larva. Fig. 2.—Unengorged female, dorsal view. Fig. 3.—Male, dorsal view. Fig. 4.—Unengorged nymph (balsam mount). Fig. 5.—Male, ventral view. Fig. 6.—Unengorged female, ventral view. Fig. 7.—Engorged female, dorsal view. The Pacific Coast tick, *Dermacentor occidentalis:* Fig. 8.—Male, dorsal view. Fig. 9.—Male, ventral view. Fig. 10.—Unengorged female, dorsal view. Fig. 11.—Unengorged female, ventral view. Fig. 12.—Fully engorged female, dorsal view.......... 152

XIII. The rabbit Dermacentor, *Dermacentor parumapertus marginatus:* Fig. 1.—Unengorged larva. Fig. 2.—Unengorged nymph (balsam mount). Fig. 3.—"Deposited-out" female, dorsal view. Fig. 4.—Male, dorsal view. Fig. 5.—Unengorged female, dorsal view. The tropical horse tick, *Dermacentor nitens:* Fig. 6.—Unengorged larva. Fig. 7.—Unengorged nymph (balsam mount). Fig. 8.—Engorged female, dorsal view. Fig. 9.—Male, dorsal view. Fig. 10.—Unengorged female, dorsal view. Fig. 11.—Engorged nymph, ventral view. Fig. 12.—Engorged nymph, dorsal view. Fig. 13.—Engorged female, ventral view. Fig. 14.—Male (balsam mount)............... 160

Page.

PLATE XIV. The Rocky Mountain spotted-fever tick, *Dermacentor venustus:* Fig. 1.—"Deposited-out" female with eggs. Fig. 2.—Unengorged larva. Fig. 3.—"Deposited-out" female, frontal view. Fig. 4.—Engorged larva. Fig. 5.—Engorged female, dorsal view. Fig. 6.—Unengorged female, dorsal view. Fig. 7.—Male, dorsal view. Fig. 8.—Male, ventral view. Fig. 9.—Unengorged female, ventral view 164

XV. The American dog tick, *Dermacentor variabilis:* Fig. 1.—Unengorged larva. Fig. 2.—Unengorged nymph (balsam mount). Fig. 3.—Engorged nymph about to molt to female. Fig. 4.—Engorged nymph about to molt to male. Fig. 5.—Male, dorsal view (Texas form). Fig. 6.—Unengorged female, dorsal view. Fig. 7.—Male, dorsal view (Oregon form). Fig. 8.—Unengorged female, ventral view. Fig. 9.—Male, ventral view. Fig. 10.—Engorged female, dorsal view. Fig. 11.—Engorged female, ventral view 192

TEXT FIGURES.

FIG. 1. The fowl tick, *Argas miniatus:* Distribution in the United States and in part of the West Indies 48
2. The spinose ear tick, *Ornithodoros megnini:* Distribution 63
3. The black-legged tick, *Ixodes scapularis:* Distribution in the United States 78
4. The rotund tick, *Ixodes kingi:* Distribution in the United States 84
5. The rabbit tick, *Hæmaphysalis leporis-palustris:* Distribution in the United States 91
6. The brown dog tick, *Rhipicephalus sanguineus:* Distribution in the United States 104
7. The North American cattle tick, *Margaropus annulatus:* Distribution in the United States 113
8. The gopher-tortoise tick, *Amblyomma tuberculatum:* Distribution 125
9. The gopher-tortoise tick: Vesica biloba 127
10. The Gulf Coast tick, *Amblyomma maculatum:* Distribution in the United States 137
11. The lone star tick, *Amblyomma americanum:* Distribution in the United States 143
12. The Cayenne tick, *Amblyomma cajennense:* Distribution in North and Central America 153
13. The rabbit Dermacentor, *Dermacentor parumapertus marginatus:* Distribution 160
14. The Rocky Mountain spotted-fever tick, *Dermacentor venustus:* Distribution in the United States 167
15. The Pacific Coast tick, *Dermacentor occidentalis:* Distribution in the United States 183
16. The American dog tick, *Dermacentor variabilis:* Distribution in the United States 192
17. The tropical horse tick, *Dermacentor nitens:* Distribution in North America and West Indies 199

THE LIFE HISTORY AND BIONOMICS OF SOME NORTH AMERICAN TICKS.

INTRODUCTION.

During the course of investigations of the biology of the North American fever or cattle tick, conducted by the Bureau of Entomology, with headquarters at the field laboratory at Dallas, Tex., many other species of ticks were met with, some of which are of considerable economic importance. In view of their importance as ectoparasites and the part that several are known to play in the transmission of disease, and in view of the further fact that comparatively little was known of their life history and bionomics, it was decided that the investigations should be extended to include as many of the species as possible.

During 1905 a few notes were made upon ticks other than the cattle tick (*Margaropus annulatus*), which was at that time being studied. These miscellaneous notes were consolidated with those of 1906 during the winter of 1906–7 and published in Bulletin 72 of this bureau, together with the results of studies of the cattle tick. In 1907 further attention was given to those species which could be obtained for study. During the summer of that year valuable information was received from Prof. C. P. Lounsbury, who visited the laboratory. In 1908 the study of various species was taken up more extensively. The work was confined principally, however, to those species occurring in Texas. In 1910 an investigation of the Rocky Mountain spotted-fever tick (*Dermacentor venustus*) was undertaken by the bureau in cooperation with the Montana Agricultural Experiment Station and the Bureau of Biological Survey. Incidental to the work on the spotted-fever tick studies were undertaken on the life histories and habits of a number of species of ticks occurring in the western United States, and several species not herein discussed are at the present time being studied. Our knowledge of the life histories of some of these species is rather complete, but it seems desirable to withhold from publication the results of investigations of these species until further data are accumulated.

This tick investigation has been conducted, throughout, under the general direction of Mr. W. D. Hunter, from whom the writers have received many helpful suggestions. Mr. W. A. Hooker had direct charge of the investigation from its inception until September 15, 1908, when Mr. F. C. Bishopp took direct charge of the investigation and has carried it forward. Mr. H. P. Wood's connection with the work has been continuous since November, 1907. Mr. J. D. Mitchell and Mr. F. C. Pratt (now deceased) contributed valuable assistance by collecting material and making notes on host relations and economic status. Mr. W. V. King, acting under the direct supervision of Prof. R. A. Cooley, of the Montana Agricultural Experiment Station, has, by the collection of several hundred lots of ticks in the Northwestern States, supplied a large amount of information on the hosts of *Dermacentor venustus* and other species and some information upon the geographical distribution of these species. Prof. Cooley has also aided materially in several ways, including the sending of a number of specimens of *Ixodes kingi*, which were used in the studies of that species published herein. Several correspondents, particularly in the Western States, have furnished a large number of lots of ticks which have been of much value in the work. Mr. C. E. Hood, Mr. G. N. Wolcott, and Mr. G. W. Hood are responsible for a few of the counts of eggs, and these gentlemen, as well as Mr. E. A. McGregor and Mr. J. Jacobs, have assisted in the summarization and tabulation of records.[1]

CONCERNING TICKS IN GENERAL.

SYSTEMATIC POSITION AND CLASSIFICATION.

The ticks form a superfamily of the order Acarina, and are closely related to the mites which produce scab, mange, and itch. The superfamily Ixodoidea, to which all the ticks belong, is composed of two families, namely, the Argasidæ, represented in this country by 2

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[1] Credit for taking the photographs used in making the plates in this bulletin should be given as follows:

H. P. Wood: Plate I, fig. 1.

F. C. Bishopp: Plate I, fig. 6; Plate III, fig. 2; Plate XIV, fig. 5.

W. E. Hinds: Plate II, fig. 1; Plate VI, fig. 10; Plate VII, figs. 1, 5, 6; Plate VIII, fig. 5; Plate XI, fig. 3; Plate XIII, fig. 14.

W. A. Hooker: Plate I, figs. 4, 5; Plate III, figs. 1, 3, 4; Plate V, figs. 1, 4; Plate VI, figs. 11, 12, 15; Plate VII, figs. 2, 4; Plate VIII, figs. 1, 2; Plate IX, figs. 1–8; Plate X, figs. 1–10; Plate XI, figs. 1, 4, 5, 7, 8, 9; Plate XII, figs. 1, 4, 7; Plate XIII, figs. 1–13; Plate XIV, fig. 2; Plate XV, figs. 1–4, 10, 11.

G. N. Wolcott: Plate I, figs. 2, 3; Plate II, fig. 2; Plate III, figs. 5–8; Plate IV, figs. 1, 9; Plate V, figs. 2, 3, 5–8; Plate VI, figs. 1–9, 13, 14, 16, 17; Plate VII, figs. 3, 7–10; Plate VIII, figs. 3, 4, 7–11; Plate XI, figs. 6, 10; Plate XII, figs. 2, 3, 5, 6, 8–12; Plate XIV, figs. 1, 3, 4, 6–9; Plate XV, figs. 5–9, genera and 6 (possibly 7) species, and the Ixodidæ, represented by 8 genera, 36 species, and 3 varieties, as follows:

- Ixodoidea
  - Argasidæ
    - Argas (2 species in the United States).
    - Ornithodoros (4 species in the United States).
  - Ixodidæ
    - Rhipicephalinæ
      - Rhipicephalus (1 species in the United States).
      - Margaropus (1 species in the United States).
      - Hæmaphysalis (2 species in the United States).
      - Dermacentor (8 species and 1 variety in the United States).
    - Ixodinæ
      - Ixodes (16 species and 2 varieties in the United States).
      - Ceratixodes (2 species in the United States).
      - Aponomma (1 species in the United States).
      - Amblyomma (5 species in the United States).

The type locality of 12 of the recognized species occurring in this country is outside of the United States. Of these 12 species 2 were described by Linnæus (1758), 2 by Fabricius (1794), 1 by Leach (1815), 3 by Koch (1844), 1 by Guérin (1849), 1 by Cambridge (1876), and 2 by Dugés (1883).

Many of the names of supposedly new species have proved to be synonyms. Nymphs have occasionally been described as new species. The sexual dimorphism and the variation in the amount of blood engorged at the time the specimens were collected account for many of the synonyms. Of the 8 species described by Say in 1821 all but 3 are synonyms or remain unrecognized, while of the 5 described by Fitch (1872) all are synonyms or remain unrecognized. Of the 9 described by Packard (1868, 1869, 1872) 5 are recognized as distinct species.

The first work upon the classification of the ticks of this country was that of Dr. Marx (1893), whose studies were soon after terminated by his death.

In 1896 Dr. L. G. Neumann published the first part of his revision of the Ixodoidea of the world, the last part of which appeared in 1901, but which has been followed from year to year by a series of "Notes." Unfortunately this valuable work, in its original form, is accessible to only a few. However, a concise summary has recently been published (1911).

The first great step in the classification of the ticks of this country was taken in 1901, when the important work by Drs. Salmon and Stiles, on the cattle ticks of the United States, was published. With the appearance, in 1908, of the revision of the Ixodoidea of the United

States,[1] by Mr. Nathan Banks, a work became available by means of which most of the ticks of this country can be readily identified. Since this work appeared several new species have been described by Messrs. Banks (1910), Stiles (1910), and Bishopp (1911b),[2] so that at present 42 species and 3 varieties representing the genera Argas, Ornithodoros, Amblyomma, Aponomma, Ceratixodes, Dermacentor, Hæmaphysalis, Ixodes, Margaropus, and Rhipicephalus, are known to occur within our borders. A valuable monograph of the Ixodoidea is being published by Nuttall, Warburton, Cooper, and Robinson. Two parts, dealing with the Argasidae, the classification of ticks, and the genus Ixodes, have been issued.

A detailed illustrated account of the general structure of ticks, to which reference should be made, has been given by Salmon and Stiles (1901, pp. 387–398). It may be well, however, to give a brief description of the so-called capitulum or head, bearing the palpi and the haustellum, the latter of which consists of the mandibles, mandibular sheaths, and hypostome, which are inserted into the skin of the host. The capitulum is a small subtriangular piece that articulates with the anterior margin and usually within a slight emargination of the corneous shield, or scutum, which in the ixodid female forms the front part of the dorsum and in the male covers the greater part of the body. The hypostome, or labium, which lies underneath the mandibles, is an elongated dart or spatulate structure, which is composed of 2 lateral symmetrical halves bearing many hooks or denticles directed backward, so that when embedded in the flesh it can not be forcibly withdrawn with ease. The mandibles, 2 in number, are terminated anteriorly by either 2 or 3 processes, known as apophyses, that are used for piercing the flesh and making an entrance. The mandibular sheaths surround the base of the mandibles and extend backward on the dorsal side of the haustellum. Upon each side of the haustellum, applied closely thereto, are the palpi, which are grooved on the inner margin.

There is considerable variation in the size of the individual ticks of a single species, among both males and females. The engorged nymphs also vary in size, the larger usually being prefemales.[3] Under the several species measurements will be found which indicate the variation. The color, especially of the immature stages, is also quite variable. In engorged larvæ and nymphs of some species there is a variation from dark brown to pink and pale gray. This is apparently due to the proportionate amount of blood, lymph, and inflammatory exudate that has been engorged.

---

[1] For the classification of the ticks the worker is referred to Mr. Banks's Revision of the Ixodoidea (1908). Descriptions of adults, aside from their size and coloration, have been omitted in the present work, as they will be found in Mr. Banks's Revision.

[2] See Bibliographical references, p. 205.

[3] The terms "premale" and "prefemale" have been used to denote those individuals, not yet molted to adults, in which the sex can be recognized.

The internal anatomy of ticks has been studied by a number of investigators, among whom mention should be made of Heller (1858), Pagenstecher (1861), Williams (1905), Allen (1905), Christophers (1906), Bonnet (1907), Nordenskiöld (1908, 1909), and Samson (1909).

COLLECTING, PRESERVING, AND MOUNTING.

Owing to the fact that very few entomologists or zoologists have had experience with the systematic collection of ticks a few suggestions along this line may prove of value. The writers have found that in many instances zoologists have received and handled specimens of skins and living animals to which ticks were attached and entirely overlooked these parasites. In other cases the ticks were seen but were not preserved. The ease with which this class of parasites may be preserved should encourage zoologists to keep on the lookout for them and to collect all specimens seen.

Persons who collect specimens of ticks should record the host, point of attachment, date, and locality. All parts of the host, including the inside of the ears, should be closely examined. Upon the discovery of a female, and before removing it, the collector should search closely for the male, which may be attached near by. A pair of forceps will be found useful in removing the smaller ticks. Those with short mouthparts are readily removed without injury, but many, particularly those of the genus Ixodes, are usually so firmly attached that the body of the tick will be separated from the capitulum unless the latter is firmly grasped. Some ixodologists have recommended the application of a penetrating oil and waiting for the tick to loosen its hold, but this will seldom be found necessary.

In collecting ticks from small animals which have been shot or trapped, a supply of small cotton bags should be at hand into which the host can be placed as soon as shot and the bag firmly tied to prevent the escape of the ticks. In this way specimens may be examined at the collector's convenience and notes may be made on the habits of the ticks. If the host animal is too large to be bagged it should be examined at once over some white surface, such as white cotton cloth spread over the ground. The importance of immediate examination is emphasized, as the writers have found that larvæ of the rabbit tick and of other species with short hypostomes commence to leave the host within a very few minutes after the animal is killed. Ticks with long hypostomes, such as Ixodes, are sometimes unable to detach, and therefore remain upon the animal. In a number of instances living and dead ticks have been found clinging to the skins of animals which have been nailed on a wall for several days.

The collection of ticks from herbage, on which they are awaiting a host, may best be done by dragging a white cloth, preferably of wool, over bushes, grass, etc. An ordinary insect beating net may also be employed. Fruitful results have been found to attend the examination of the dens of animals, nests and regular roosting places of birds, and the ground in the vicinity of resting and watering places of mammals. Pill boxes have been found to be satisfactory receptacles for the ticks when collected.

In preserving we have usually used 80 per cent alcohol or a mixture consisting of 60 parts alcohol, 1 part formalin, and 39 parts water. Adult specimens, particularly males with bright color markings, should be mounted on pins, as well as preserved in alcohol. For microscopical study specimens should be mounted in Canada balsam on slides. The contents of the body should first be teased out in hot water, through a slit made at the posterior end of the body. Specimens can then be readily cleared by boiling in a 10 per cent solution of caustic potash (KOH), care being taken that the clearing be not carried too far. The method employed by Dr. C. W. Stiles consists in soaking the specimens in from 2 to 5 per cent caustic-potash solution for periods varying from 12 to 96 hours, after which all of the soft body content is removed, and after passing the specimens through water, the alcohols, and xylol or other clearing agents, the specimens are mounted in balsam.

ECONOMIC IMPORTANCE.

Ticks are of economic importance (1) as agents in the transmission of infectious diseases, and (2) as external parasites, both of man and the lower animals. At least two distinct diseases of man and eight or more of domestic animals are known to be thus transmitted, at least 17 species of ticks being involved as carriers. Of these diseases one of man and one of cattle occur, and one of fowls is suspected to occur, in the United States, while several others would undoubtedly obtain a foothold were they once introduced.

It has been estimated by Dr. Mohler (1905) that the cattle tick alone is the source of approximately $40,000,000 annual loss in the United States. Mayer (1906) has estimated the annual loss as nearly $100,000,000.

These parasites are of considerable importance as external parasites, particularly in the Southern States, owing not only to their irritation and great drain upon stock through removal of blood, but also to their indirect effect as well. In one of Theiler's experiments (1909a) a horse that was infested with *Margaropus decoloratus* died as a result of infestation from acute anemia due to the withdrawal of blood.

Within 3 days 14 pounds, by weight, of ticks which had dropped from this horse were collected, and this amount represented only about one-half of the total number of ticks which engorged upon it. After dropping, their places of attachment furnish points at which the screw-worm fly (*Chrysomyia macellaria*) deposits its eggs, the maggots from which then readily enter the host. In the Southwestern States the appearance of equines is frequently injured by screw-worms, which gain entrance at the points in the ears where ticks had been attached, burrow, and destroy the supporting cartilage, causing the ears to lop over. This condition is commonly known as "gotched." Not the least of all is the frequent annoyance which man suffers as the result of the attachment of ticks to his body.

The ticks which molt upon the host, instead of having to wait long periods to find another, merely continue sucking blood from the same animal. As a result these ticks reproduce very rapidly and frequently become of much greater importance as external parasites than species which drop to molt. This is the case with the cattle tick. Those which drop to molt have overcome this great disadvantage by becoming more resistant to heat and cold and by having gained the power to withstand much longer periods of fasting. Certain members of the subfamily Ixodinæ, while not occurring in such great numbers on animals as in the case of species which molt on their hosts—all of which belong to the subfamily Rhipicephalinæ—are frequently of considerable importance as pests, owing to the fact that the great length of the hypostome permits deep penetration. As the result of this deep penetration by the Ixodinæ, an inflammation is produced which frequently results in suppuration. Often in the attempt to remove ticks belonging to this latter class from the body of the host, the capitulum is separated from the body of the tick and remains embedded in the host.

The periods in the life history of ticks of particular importance economically and which should be determined are: *Longevity*, or the period required for starvation while awaiting a host; *minimum parasitic period*, which is used in connection with the preoviposition and incubation periods to determine the time that tick-free areas may be used after infested cattle are turned in before the areas become infested; *maximum parasitic period*, or the period required for cleaning the host of all ticks (except males) when kept in tick-free inclosures; *preoviposition period and minimum incubation period*, used with the minimum parasitic period to determine the time that tick-free lots may be used before becoming infested; *stage or stages of imbibition of infection* and the *stage or stages in which infection is transmitted*, i. e., in the case of species involved in disease transmission.

HISTORY OF THE BIOLOGICAL STUDY OF TICKS.

The first studies made of the life history and habits of ticks were those of Dr. Cooper Curtice (1891, 1892a, b) on the cattle tick (*Margaropus annulatus*) conducted in cooperation with the Texas Agricultural Experiment Station at about the time that Drs. Smith and Kilborne were investigating the rôle of that species in the transmission of splenetic fever. From the time of these investigations by Dr. Curtice up to 1898 little attention seems to have been given to the biology of ticks other than this species, although a preliminary study was made of *Amblyomma variegatum* (*Hyalomma venustum*) in Antigua, by C. A. Barber (1894–95).

In 1898 Dixon and Spreull reported studies made of *Margaropus decoloratus* and the same year Prof. C. P. Lounsbury, the entomologist of Cape Colony, British South Africa, began his classic studies of the Ixodoidea. Since that time Lounsbury has worked out the life history and habits of a large number of South African species. During the course of these studies he has demonstrated the transmission by ticks of three distinct diseases of domestic animals and the pathogenicity of at least seven species of ticks and has determined the stages of imbibition and of inoculation of the hosts with the disease-producing organisms.

In 1898 Dalrymple, Morgan, and Dodson, of the Louisiana Agricultural Experiment Station, published a detailed account of experiments relating to the life history of the cattle tick. The information which they furnished upon the longevity of the "seed ticks" served as a basis for the feed-lot and pasture-rotation system for cleaning stock and pastures of the cattle tick. In 1899 Prof. H. A. Morgan published further information upon the life history of the cattle tick and included data upon the biology of *Amblyomma americanum*, *Dermacentor variabilis* (*electus*), and *Ixodes scapularis* (not *ricinus*).

In 1899 E. G. Wheler, in England, published an account in which he reported studies made of *Ixodes ricinus* and the same year C. J. Pound published notes on the Australian cattle tick (*Margaropus annulatus australis*). In 1903, Dr. H. Kossel and his coworkers published an account of studies of the biology of *Ixodes ricinus* in a report of investigations made in Germany in which they found it to transmit bovine piroplasmosis. During the course of his investigations of the various protozoan diseases of animals in South Africa, Dr. Arnold Theiler, veterinary bacteriologist to the Transvaal, has added much to our general knowledge of the biology of ticks. Dr. H. T. Ricketts, in connection with his investigation of Rocky Mountain spotted fever, has published information from time to time (1907, 1909a, b) upon the life history and habits of *Dermacentor venustus*. Prof. R. A. Cooley (1908, 1911) and W. D. Hunter and F. C. Bishopp (1911a, b) have also published studies made of that species. Capt. S. R. Christophers, working in India, has studied *Rhipicephalus sanguineus* (1907) and made observations on *Ornithodoros savignyi* (1906). In South America, Dr. F. Lahille, of Argentina (1905), has studied *Margaropus annulatus australis* and Dr. C. J. Rohr, of Brazil (1909), has conducted extensive investigations on six species. Newstead reported in 1909 on studies made in Jamaica. Among others who have studied the cattle tick are Ransom (1906), Newell and Dougherty (1906), Schroeder (1907), Hunter and Hooker (1907), Cary (1908), Cotton (1908), and Graybill (1911). Many others have recorded miscellaneous observations on different species. Preliminary notes on several species were published by Hunter and Hooker in 1907, and further information has since been published by Hooker (1908, 1909a, b, c).

GEOGRAPHICAL DISTRIBUTION.

The ticks that commonly attach to the domestic animals have been widely disseminated on the hosts so that now many of them are only limited by climatic zones. Of the several meteorologic factors which control their distribution cold appears to be the most important, although excessive heat and variation in humidity are also important. Thus in America we find the tick species most abundant in the Tropical and Lower Austral zones and the least so in the Boreal Zone. Several native species, notably *Margaropus annulatus, Amblyomma maculatum,* and *Argas miniatus* rarely appear above the Lower Austral Zone, while *Amblyomma tuberculatum, A. dissimile, A. cajennense,* and *Dermacentor nitens* occur only in the Tropical or Gulf strips of the Lower Austral Zone. Our two species of Ceratixodes, namely, *putus* and *signatus,* apparently occur in the Boreal Zone only.

Some species remain attached to their hosts for long periods (particularly the males) and may be carried great distances. This has resulted in numerous records which must be rejected in determining the normal distribution of a species. The approximate zonal distribution of our species is shown in Table I.

TABLE I.—*The zonal distribution of North American ticks.*

	Species.	Boreal region.			Austral region.						Tropical region.
		Arctic.	Hudsonian	Canadian.	Transition.		Upper Austral.		Lower Austral.		Tropical.
					Transition.	Alleghanian.	Upper Sonoran.	Carolinian.	Lower Sonoran.	Austroriparian.	
1	Amblyomma americanum	Doubtful	Doubtful	Occurs		Occurs		Common		Abundant	Occurs.
2	Amblyomma cajennense								Common		Abundant.
3	Amblyomma dissimile										Common.
4	Amblyomma maculatum								Abundant	Abundant	Occurs.
5	Amblyomma tuberculatum								Doubtful	Common	Occurs.
6	Aponomma inornata				Occurs		Occurs		Occurs		
7	Argas brevipes						Occurs				
8	Argas miniatus						Rare		Abundant	Occurs	Common.
9	Ceratixodes putus	Occurs	Occurs								
10	Ceratixodes signatus		Occurs		Occurs						
11	Dermacentor albipictus			Occurs	Abundant	Occurs	Common				
12	Dermacentor nigrolineatus			Occurs		Occurs		Occurs	Occurs		
13	Dermacentor nitens								Common		Abundant.
14	Dermacentor occidentalis			Common	Abundant		Common		Occurs		
15	Dermacentor parumapertus						Occurs				
16	Dermacentor parumapertus marginatus						Common		Abundant		
17	Dermacentor variabilis	Doubtful	Doubtful	Occurs	Occurs	Occurs	Occurs	Common	Occurs	Abundant	
18	Dermacentor venustus		Doubtful	Common	Abundant		Common				
19	Hæmaphysalis chordeilis					Occurs			Occurs		
20	Hæmaphysalis leporis-palustris			Occurs	Common	Common	Abundant	Common	Abundant	Abundant	Occurs.
21	Ixodes angustus			Common	Common						
22	Ixodes angustus woodi								Occurs		
23	Ixodes arcticus		Occurs								
24	Ixodes banksi							Occurs			
25	Ixodes brunneus					Occurs	Occurs	Occurs	Occurs		
26	Ixodes californicus			Occurs	Common		Occurs				
27	Ixodes cookei				Occurs	Common	Common	Common	Occurs	Occurs	
28	Ixodes cookei rugosus				Common						
29	Ixodes dentatus							Rare			
30	Ixodes diversifossus				Rare		Doubtful				
31	Ixodes aequalis						Rare				
32	Ixodes hexagonus							Rare			
33	Ixodes kingi			Occurs	Common		Common		Rare		
34	Ixodes marxi				Rare	Rare					
35	Ixodes pratti								Rare		
36	Ixodes scapularis							Common	Occurs	Abundant	Rare.

37	Ixodes sculptus					Occurs		Occurs		Occurs		
38	Ixodes texanus					Common				Occurs		
39	Margaropus annulatus					Rare		Occurs	Occurs	Abundant	Abundant	Occurs.
40	Margaropus annulatus australis											Abundant.
41	Ornithodoros coriaceus					Occurs		Occurs		Occurs		Doubtful.
42	Ornithodoros megnini					Rare		Common		Abundant	Rare	Doubtful.
43	Ornithodoros talaje									Occurs		Occurs.
44	Ornithodoros turicata							Rare		Occurs		
45	Rhipicephalus sanguineus									Abundant	Rare	Common.

GENERAL LIFE HISTORY.

Although ticks are able to survive long periods of fasting—some species much longer than others—development takes place only following a period of attachment during which the blood of some animal, either warm or cold blooded, must be taken into the body, i. e., they are obligatory parasites. Several writers have considered the possibility that ticks may subsist in part upon vegetable matter. Prof. Lounsbury, however, who has conducted extensive studies of these arachnids, states (1905) that he has no doubt that they derive nutrition exclusively from living animals despite the protracted periods that they often have to wait for hosts. They do, nevertheless, imbibe water from the rain or dew upon herbage or from the soil. One of the writers has observed ticks kept in tubes, on dry sand, to imbibe water from the moistened sand. Many untrained observers have reported that engorged ticks give birth to living young. Ricketts (1909a, p. 104) mentions this phenomenon as having been described to him concerning *Dermacentor venustus* by a number of residents of the Bitter Root Valley, Montana. While the origin of such erroneous statements can not be determined, one explanation to be offered is that of mistaking some of the Kermes for ticks. Thus *Kermes galliformis* has been sent to one of the authors by an entomological collector who supposed it to be a tick. With the Kermes was a statement to the effect that it had been found dead with young swarming from it.

DEVELOPMENT.

All ticks pass through four distinct life stages: (1) The egg, (2) the larva or seed tick (6-legged stage), (3) the nymph or yearling tick (first 8-legged stage), and (4) the adult. All the ixodid and one (or more) of the argasid ticks engorge and molt but twice before arriving at the adult stage. Two species of Ornithodoros are reported to remain inactive in the larval stage and pass the first molt before engorging blood. Some of the argasids molt twice or three times during the nymphal stage, and at least one species continues molting after becoming adult. The larvæ of *Ornithodoros talaje*, which species is now being studied, engorge, then drop and molt twice before the next engorgement. The ixodid ticks engorge but once as adults, and die following the completion of oviposition, while most of the argasid ticks engorge a number of times as adults, oviposition following each engorgement.

MOLTING.

There is wide variation in the molting habits of ticks, even among species of the same genus. Most of the ticks, both argasid and ixodid, molt while away from the host, and the habit of molting while attached appears to be a special adaptation. One native species (*Ornithodoros megnini* Dugès) and several exotic species (*Rhipicephalus evertsi*, *R. bursa*, *Hyalomma ægyptium*) pass the first molt upon the host, but drop for the second. A few species, including *Margaropus annulatus* and its several varieties, *Dermacentor albipictus* and *Dermacentor nitens*, pass both molts upon the host. As yet none is known to drop for the first molt and to pass the second upon the host.

HABITS.

HOST RELATIONSHIP.

Several species of ticks seem to be naturally restricted to a single genus or family of hosts, such as *Hæmaphysalis leporis-palustris* and *Dermacentor parumapertus marginatus* to the Leporidæ. Others, although attaching to some hosts more or less frequently (secondary hosts), have particular hosts (primary hosts) to which they more commonly attach. From this habit have arisen many of our common tick names, such as the cattle tick, dog tick, rabbit tick, etc.

Ticks occasionally attach themselves to animals which may be termed accidental or temporary hosts. This fact is aptly illustrated by the cattle tick, large numbers of which, in the first experiments, were repeatedly placed upon dogs by the writers, but without becoming attached. Finally, however, during the summer of 1908 several ticks attached themselves to the laboratory dogs and later, on these host animals, developed to replete females. There seems to be a rather close analogy between ticks and fleas with regard to hosts. In his revision of the Siphonaptera (1904, p. 368), Baker mentions rabbit fleas as remaining on a human being for some little time, biting frequently while there, but not frequenting the human host nor his clothing or bed. To illustrate how fleas would find these temporary hosts, he mentions the possibility of a rabbit running into a badger hole, or a mouse into a mole burrow; that the eating of a mouse by an owl or the devouring of a rat by a cat would afford favorable conditions for this temporary transference of parasites. Similar instances account for many of our accidental hosts of ticks. It thus appears that larvæ of *Amblyomma tuberculatum* become attached to hawks and owls at the time their small mammal hosts are being devoured.

Experiments conducted by the writers have shown that when confined in a bag in close proximity to the scrotum of a bovine, nearly all of the ixodids will attach. As a result of these accidental or temporary attachments for some species we have large host lists, including hosts upon which the ticks could only occasionally or never reach maturity. Prof. Lounsbury has found a peculiar habit in *Hyalomma ægyptium impressum*. As a larva, it will not feed on the large mammals, but attaches to the heads of fowls and hares, upon which the first molt is passed. Following the second molt, which takes place off the host, it attaches to almost any of the warm-blooded animals.

Mammals serve as the principal hosts of the ticks. Fowls are largely the hosts of the genera Argas and Ceratixodes, of two North American species of the genus Hæmaphysalis, and of one of Ixodes. Several species of the genera Ixodes, Amblyomma, Aponomma, and Hyalomma are also occasionally parasitic upon fowls, and in the immature stages a number of others may attach to fowls. A large number of species have been collected from reptiles, several from amphibians, and two from beetles.

ADAPTATIONS.

Natural selection appears to have resulted in special adaptations both of function and structure and of the habits of ticks. All ticks must find hosts and attach at least once, some as many as four times, before they can reproduce. This necessity has resulted in special adaptations of function and structure for attachment.

The adaptation of function is shown in the use made by the ixodid ticks of the front pair of legs. As one approaches the free tick, these legs can be seen waving in the air, while with the others it holds to its support. When a host comes in contact with them, they cling to it most tenaciously with these legs, to determine which fact one has but to pass a finger rapidly over a cluster of the seed ticks. An examination shows the legs to be especially fitted for attachment.

The adaptation of structure for protection is represented in the case of the engorged larvæ of *Argas miniatus.* Up to within a few hours of dropping, these larvæ are globular in shape; but at this time they flatten and assume the typical Argas shape. This flattened form, common to all of the other stages, permits the ticks to crawl rapidly and to secrete themselves in cracks and crevices protected from the wily fowl. In the Ixodinæ we find what may be considered specially adapted mouthparts, which, being unusually long, penetrate deeply and prevent their easy removal.

In the adaptation of habits favorable to attachment and protection we find most striking illustrations of natural selection. Such adaptations are: First, in molting; second, in attachment to any host; third, to habits of host; and, fourth, acquired greater vitality. There is a great disadvantage in dropping to molt, for it necessitates long periods of waiting, and results in a high percentage of mortality from not finding a host. This disadvantage is overcome by some species which have acquired the habit of molting on the host, for example, by Margaropus and by *Dermacentor nitens* and *D. albipictus.*

To this class belong several other species which have partially overcome this disadvantage by passing the first molt upon the host. Two representatives of this class are the South African species *Rhipicephalus bursa* and *R. evertsi*. It has been overcome entirely by *Ornithodoros megnini*, the spinose ear tick, in a somewhat different way—that is, by passing the first molt upon the host, then feeding sufficiently as a nymph so that following the second molt, which takes place off the host, engorgement as an adult is unnecessary for oviposition and probably never occurs.

Even in species most diverse in their tastes there are hosts especially favored. This in some cases may be accounted for by the great numbers of that host available. In the class which has adapted its habits to the habits of the host, the ticks are confined largely to a host or group of hosts with similar habits. The species *Hæmaphysalis leporis-palustris*, commonly known as the rabbit tick, has adapted itself to the habits of the Leporidæ, the hares and rabbits, and only accidentally attaches to other hosts. It is the habit of the hares and rabbits to remain more or less inactive during the day in their "forms," or resting places, protected by a clump of grass or bushes from enemies, such as birds of prey, their activity being largely at night. The writers have found that this tick following engorgement drops largely during the day; in other words, when the hares and rabbits are in their forms or resting places, to which they return to pass the day. Thus, when the ticks have hatched or molted and are ready to attach, they have little trouble in finding the host. This same habit has been acquired by the fowl tick, *Argas miniatus*, which, in the engorged larval stage, the writers find, drops only at night (except accidentally), when its host, the fowl, is upon the roost. Thus when ready to reattach it is near and readily finds the host, whereas had it dropped during the day when the fowl was on the "run" the chances of its finding a host would be greatly lessened. A habit apparently acquired by *Ornithodoros megnini* is that of crawling to a height of several feet from the ground as a nymph before molting and depositing its eggs; thus when the seed ticks appear ready to attach they will be rubbed off by the horses, cows, or other host, and readily find access to the ear. The extreme agility of the unengorged adults of *Dermacentor parumapertus marginatus* and *Rhipicephalus sanguineus* undoubtedly greatly aids these species in finding a host and in finding a place of attachment before being dislodged by the host. These species furnish what evidence we now have of the adaptation of habits to the habits of the host, but it seems probable that similar habits will be discovered in other species when they have been given sufficient study.

Dr. Nuttall has recently (1911a) discussed a structural adaptation which he believes to have resulted from the interrelationship of the hosts and their parasites. He observes that in certain species of Ixodes which normally infest wandering animals the hypostomes of the males are strongly armed, while others which attack animals with fixed habitats have practically no armature on their hypostomes. He believes that in some cases the males of these species may never attach to the host. With those species which feed upon wandering hosts, it is necessary for the males, as well as the females, to attach.

It seems probable that in the species which drop to pass their molts greater resistance to high and low temperatures and the power to withstand long periods of fasting have been acquired. On the other hand, some of the species which have acquired the habit of molting on the host have lost in this power of resistance.

As related to protection, the adaptation of habits may be considered under accelerated engorgement, attachment to favorable part of the host, nocturnal habits, habits while awaiting hosts, and habits during molting and oviposition.

Of accelerated engorgements we have several instances among the ticks. These are best illustrated by the fowl tick, which engorges within a few hours at the most. Prof. Lounsbury argues that such ticks are descendants from forms which remained for days at a time on the host. This view is given weight by the habit of the larvæ of the fowl tick, of remaining upon the host for several days to engorge. In the cattle tick, *Margaropus annulatus*, after it has become about one-third engorged, which requires a number of days, complete engorgement takes place and the ticks drop within a comparatively few hours. In this way the chances of destruction, due to removal by predaceous enemies, such as birds, by crushing by the host, or by attack by parasites, have been very much reduced.

Again we find species which have adapted their habits for purposes of protection by attaching to favorable parts of the body, as have *Ornithodoros megnini* and *Dermacentor nitens*, which attach to the inside of the ears. The species of Hæmaphysalis found upon quail, field larks, and other ground-feeding birds in Texas, Louisiana, and Florida, appear to attach only to the head, a place from which they are not easily removed by the fowl. Perhaps the most highly developed habit acquired by ticks for protection is the nocturnal habit of species of the genus Argas. Through this habit of resting during the daytime they escape detection by the fowls, which, upon discovering them, devour them with great avidity. At night the fowls go to roost and the ticks have little trouble in finding them and engorging at a time when their hosts are inactive; thus the ticks largely escape detection and destruction.

The habit of the immature stages of the gopher-tortoise tick (*Amblyomma tuberculatum*) of burying themselves in the soil after becoming engorged appears to be an adaptation for protection and to provide moisture for molting.

The clustering of the larvæ undoubtedly decreases the rapidity of drying out and thus increases the longevity of that stage. The larvæ of *Dermacenter albipictus*, a species which is now being studied, remain in dense clusters for months on the sand in tubes without making any effort to find a host. This seems to be a protective habit developed in order to pass the time between generations.

The engorged females of most of our species have a habit of finding protection as soon after dropping as possible in order that they may deposit their eggs unmolested.

MATING AND FECUNDATION.

Fertilization may take place during attachment or after the females have engorged and left the host. Several instances have been reported in which mating has taken place before attachment to a host, but whether such unions result in fertilization has not been determined. Thus E. G. Wheler (1899, p. 632) collected unengorged specimens of *Ixodes ricinus* on herbage which mated when kept in confinement. He also observed mating of a male and an engorged female taken from a deer.

Mr. J. D. Mitchell, as reported by Hunter and Hooker (1907), observed a pair of *Amblyomma americanum* clinging to herbage with the mouthparts of the male inserted in the genital orifice of the female, and Mr. C. W. Howard (1909) reports a similar observation in the case of *Rhipicephalus ecinctus.*

Dr. H. T. Ricketts (1909, p. 99) states that with *Dermacentor venustus* fertilization will take place even when the ticks are not on an animal host. Just what he intended to convey is not clear, but it would appear that he meant that copulation took place away from the host, probably after removal. The writers have observed this habit in *Ixodes scapularis*, both upon and off the host. An unengorged, unattached female taken in the field from a hunting dog and placed in a pill box with unattached males taken from the same dog was shortly after found in this relation with one of the males. These observations do not prove, however, that fertilization follows such unions, and investigations may show that the engorgement of blood by one or both sexes is necessary.

With the Argasidæ fertilization takes place after the adults have engorged and left the host. Thus the nymphs of *Ornithodoros megnini* leave the host, molt, and without further feeding are fertilized and commence oviposition. Prof. Lounsbury states (1903a, p. 268) that in *Argas miniatus* mating takes place a few days after engorgement. He says that the male inserts the rostrum into the genital orifice of the female but that he does not know the significance of this action. We have observed copulation in *Argas miniatus* in a number of instances. The act has been witnessed most frequently a few hours after engorgement. The male crawls beneath the female and inserts the hypostome into the female genital orifice. In about five minutes the mouth parts are withdrawn and the male moves slightly forward and deposits a large spermatophore, the end of which is inserted in the female aperture. The contents of the spermatophore appear to be pressed out by the body of the male. The empty spermatophore is usually left attached to the posterior margin of the genital opening of the female. This collapsed sack was found to measure about 0.387 mm. long (parallel with the axis of the tick) by 0.502 mm. broad. Nuttall and Merriman (1911) have made very careful observations on the copulation of *Ornithodoros moubata;* the process is very similar to that which occurs in *Argas miniatus.*

With the Ixodidæ copulation usually takes place on the host, although males of a number of species have been observed with the mouth parts inserted in the genital openings of females while off the host. This habit was first observed by De Geer (1778). Among the ixodid ticks it appears to be the most common in species of the genus Ixodes, having been observed by Wheler (1906, p. 425) in *I. ricinus* and *I. hexagonus* and by the writers in *I. scapularis* and *I. californicus.* Samson (1909), who has made observations on this act in *Ixodes ricinus,* states that no spermatozoa were found in the female genital pore when a male which had its mouthparts inserted was removed. However, males were observed to withdraw the mouthparts and to bring the genital pore into contact with that of the female, then reinsert the beak as though pushing the spermatophore into the female orifice. This habit of the male in introducing the hypostome into the vulva, so commonly observed among species of the genus Ixodes, has been less frequently observed in other ticks. Wheler (1906, p. 425) has also observed the habit in *Ceratixodes putus.* Dönitz (1905, p. 125) reports its occurrence in *Rhipicephalus appendiculatus* and *R. evertsi* as well as in *I. ricinus,* and Lounsbury (1905) has observed it one or more times in *Amblyomma hebræum, R. evertsi, Margaropus decoloratus, Argas persicus,* and *Ornithodoros savignyi cæca,* as well as in *I. pilosus* (1900c).

With the species which molt upon the host, the male usually reattaches very shortly after the nymphal skin is shed and, following a short period of feeding, goes in search of the female. In most of the species which drop to molt it seems to be necessary that the male attach and engorge blood before the sexual instinct becomes manifest. The period required for fecundation appears to vary considerably. Some species, namely, *Margaropus annulatus, Der-*

macentor nitens, *Rhipicephalus sanguineus*, and others, remain mated for nearly the entire period that the female remains attached. Others, including the species of Amblyomma that we have studied, remain in the position of copulation for comparatively short periods.

Considerable difficulty has been experienced by the writers in getting the sexes of the species of Amblyomma and Dermacentor (except *D. nitens*) to copulate, and there remains much to be learned in relation to this habit.

Prof. Lounsbury has made some interesting observations of the mating of *Amblyomma hebræum*, a species the habits of which are quite remarkable. He has found that the female goes in search of the male, the latter accepting the female only after having attached and fed for several days.

SECRETIONS.

Several investigators have found that ticks secrete substances that prevent the coagulation of blood. Thus Sabbatini (1898) demonstrated that the bodies of *Ixodes ricinus*, both male and female, contain an anticoagulin, and Nuttall and Strickland (1908) demonstrated the presence of anticoagulin in the salivary glands and intestines of *Argas miniatus*. Christophers (1906, pp. 10, 45) reports observations first made by Donovan of a secretion from the coxal glands of *Ornithodoros savignyi* when engorging. This secretion, which was abundant (several large clear drops forming in quick succession), is alkaline to litmus and has a marked effect in preventing the coagulation of blood. A similar secretion has been observed by the writers to be exuded from the coxal glands of *Ornithodoros turicata*, *O. talaje*, and *O. megnini*. Studies of the glands of ticks have recently been made by Elmassian (1910) and Künssberg (1911).

EXCRETION.

All ticks excrete more or less, particularly while attached to a host and engorging. During incubation and when about one-half of the period has passed, a white spot appears at one side of the egg. This spot, which is apparently an excretion of the embryo, is the first gross sign of the viability of the egg. After hatching this excretion still adheres for some time to the anus of the larva, but is finally removed. When seed ticks are hatched out in tubes the sides often become spotted with the white excretions. In the free stage after each molt small drops of either white or black excrement are voided, but it is during the engorgement of the adults that this is particularly noticeable. The ticks of the genus Dermacentor are the most offensive in this respect and none can compare with *Dermacentor nitens*, which, while engorging, constantly excretes a substance which, when dry, resembles coagulated blood.

CANNIBALISM.

A phenomenon closely related to cannibalism has been observed in a few instances. Hunter and Hooker (1907, p. 35) recorded an observation upon that habit. Among specimens of *Margaropus annulatus* which had been sent to the laboratory in pill boxes was found a male with its hypostome deeply inserted in the side of an engorged female. Another instance has come to our attention in a figure by C. A. Barber (1895) of *Amblyomma variegatum* (*Hyalomma venustum*) showing a male attached to the posterior end of an engorged female.

In two instances in the course of our investigation Mr. Wood has observed adults of *Ornithodoros turicata* to attack and imbibe a large amount of blood from the body of a recently fed adult of the same species. The specimens from which blood was taken did not seem to be injured by the bite of their fellows.

On April 18, 1910, a box was received at the laboratory which contained two females of *Dermacentor venustus* taken on a horse at Lakeside, Wash. When received the smaller female, which was slightly engorged, was attached to the fully engorged individual at a point between the genital opening and the coxa. In the evening of April 18 the small female was found to have detached, leaving the other somewhat distorted in the region of attachment. The injured female began depositing on April 21, but died a few weeks later after laying but 150 eggs, all of which were shriveled and failed to hatch.

MULTIPLICATION.

There is a great variation in the rate of multiplication of ticks, due to the fact that some species pass one or both molts while upon the host, while others drop for both. The ticks which drop for both molts must find a host three separate times before eggs can be deposited. Thus their chances of becoming adult are lessened, as compared with the species which pass both molts upon the host, by the proportion of 3 to 1. Those which drop to molt have overcome this great disadvantage to some extent through a greater resistance to heat, cold, etc., while awaiting the host, and through depositing larger numbers of eggs. It is well known by zoologists that the number of offspring produced by an animal is in inverse proportion to the chances of their reaching maturity. Thus with ixodid ticks many thousands of eggs are produced. As will be seen by the accompanying table the greatest number of eggs recorded by us as deposited by a single individual was 11,265, which were deposited by *Amblyomma maculatum*. Mégnin (1904) has recorded 12,000 eggs as being deposited by *Hyalomma ægyptium*, Barber (1895) 20,000 as deposited by *Amblyomma variegatum*, and Lounsbury (1899) estimates the maximum number deposited by *Amblyomma hebræum* at 20,000. The comparative reproductive capacity of the ticks which we have studied is shown in Table II.

TABLE II.—*Reproductive capacity of the species of ticks studied.*

Species.	Number of ticks recorded.	Number of eggs deposited.			
		Maximum.	Minimum.	Average.	Maximum number recorded by other observers.
Amblyomma americanum	12	8,330	947	3,054	6,519 (Morgan, 1899).
Amblyomma cajennense	13	4,789	2,384	3,536	7,240 (Williams by Newstead, 1909).
Amblyomma dissimile	2	1,655	1,573	1,614	1,784 (Newstead, 1909).
Amblyomma maculatum	7	11,265	4,560	8,282	
Amblyomma tuberculatum	2	5,481	2,197	3,839	
Argas miniatus	21	874	252	537	
Dermacentor nitens	12	3,392	2,149	2,784	
Dermacentor occidentalis	6	4,555	2,373	3,247	
Dermacentor parumapertus marginatus.	6	4,660	855	2,502	
Dermacentor variabilis	11	6,855	2,808	4,776	7,378 (Morgan, 1899).
Dermacentor venustus	11	7,396	2,496	5,422	4,820 (Cooley, 1909).
Hæmaphysalis leporis-palustris	4	2,240	1,112	1,517	
Ixodes kingi	3	4,706	1,556	3,179	
Ixodes scapularis	[1] 1	3,000	3,000	3,000	
Margaropus annulatus	10	4,547	2,127	3,424	5,105 (Graybill, 1911). 4,500 (Newell and Dougherty, 1906).
Margaropus annulatus australis	5	3,975	2,492	3,072	3,046 (Rohr, 1909).
Ornithodoros megnini	13	1,207	358	760	
Rhipicephalus sanguineus	12	2,616	360	1,602	

[1] Number of eggs estimated.

Figuring, on the basis of four generations in the Gulf States, that half of the resulting adults are females, and that 2,000 eggs are deposited by each female, Mayer (1906) has estimated that two Margaropus eggs carried over the winter and hatched by April 15 would increase to a total of 6,750,000,000 ticks by October 15, if all the females found hosts and developed. It is at once seen that this is a theoretical estimation, as only a small percentage of the ticks ever finds a host.

LOCOMOTION AND DISSEMINATION.

Experiments have been made by different persons to determine the part that locomotion may play in the dissemination of replete females of the cattle tick. Hunter and Hooker (1907) found them to travel 123 inches in the course of 52 minutes, always traveling away from the light. Engorged females of *Dermacentor venustus* have been observed by us to crawl as far as 33 inches in 4 minutes. They seem to crawl in the direction in which they are headed without regard to light. The engorged females of all species usually crawl into the first obscure nook, crack, or crevice that they find, and for this reason usually do not travel far from where they drop. Little has been done to determine the distance that ticks may go while in search of a host. Although the distance traveled by seed ticks, as the writers have observed them on grass in cages, is comparatively slight, the adults may be found to crawl considerable distances. This appears to be the case with the brown dog tick (*Rhipicephalus sanguineus*), which is very agile and constantly moving about when not attached. We have found the males of this species to travel from one dog to another when the hosts were lying asleep in the laboratory. The adults of *Dermacentor parumapertus marginatus* can crawl considerable distances in a comparatively short time, their movements being very rapid.

The usual method by which ticks are disseminated is by the natural movement of the hosts or by the shipment or driving of the host from one locality to another. The following are good illustrations of how far ticks may be carried upon their usual hosts: The cattle tick has been found on ponies in Michigan, as well as upon cattle at various times in the extreme northern parts of the United States prior to the establishment of a quarantine against this tick. *Amblyomma dissimile* has been brought into Texas on iguanas from the Isthmus of Tehuantepec, and according to Barber (1894, 1895) *Amblyomma variegatum* (*Hyalomma venustum*) has been introduced into the Leeward Islands on cattle shipped from Senegal, in Africa. That there is abundant opportunity for ticks to be carried long distances in this way may be seen from the fact that *Ornithodoros megnini* has been found to remain upon a host as long as 209 days before dropping. Birds, especially migratory species, may carry ticks long distances. In one instance Mr. W. V. King, of the Bureau of Entomology, found a number of engorged larvæ of a species of Ornithodoros, which appears to be confined normally to the Southern States, on the head of a bird in northern Wyoming. Among other means of natural dissemination which may be of importance are streams and floods (as mentioned by Hunter and Hooker, 1907, p. 24), high winds, and the movement of animals which are not hosts but to any of which ticks may cling for a greater or less time. Ticks may be artificially disseminated by means of the movement of various farm commodities, especially hay; by crates in which poultry or animals have been confined; by the shipment of hides of animals, and in the clothing of man.

SEASONAL HISTORY.

The seasonal prevalence of ticks varies considerably from year to year with the temperature conditions. In some species the winter is passed in the egg, unengorged larval, nymphal, or adult stages. Females which drop engorged after the approach of cold weather stand a very poor chance of surviving. Ricketts (1909a, p. 102) reports having obtained ticks, largely engorged nymphs, at Hamilton, Mont., late in December and in the first part of January from horses which had been in the hills during the winter. This species is undoubtedly *Dermacentor albipictus*, which has been found during our investigation to be present on horses and cattle in large numbers in both the nymphal and adult stages throughout the winter months. Thus it appears that even in the Boreal Zone some species are active during the winter months. When the season is not too hot and dry the ticks are most numerous during late summer and early fall. In the case of most of our species, we have found that all stages may occur on hosts at the same time of the year, there being no well-defined restriction of certain stages to any one season.

In our work with *Dermacentor venustus* we found it almost impossible to get adults to attach to hosts during the summer months. They remain quiet for long periods with their legs curled up close to the body. This, together with the fact that very few adults are seen on hosts in nature after the middle of June, seems to indicate that there is a period of æstivation during the latter part of the summer.

Mayer has considered it possible that the cattle tick, which must find but one host in order to complete its cycle of development, may, where hosts are plentiful, pass as many as four generations in a single year. As the number of generations depends entirely upon the finding of hosts, it is impossible to say what the average annual number of generations would be. With the 3-host species, on the average probably not more than one generation is passed in a year, and in many cases a period of two years or even longer may be required for a single generation.

METHODS EMPLOYED IN STUDIES OF TICKS.

RECKONING TEMPERATURE.

Although it is now generally understood that the temperature above which active metabolism takes place in insects, ticks, and other cold-blooded animals may vary with each species or even with each stage in the development of a single species, we have not attempted, in preparing this bulletin, to determine such temperatures, but have thought it best to use 43° F. as the zero of effective temperature in all our computations. However, from the data furnished with each table one can work out the approximate effective temperature for a given stage. In figuring the total effective temperature required for the incubation of eggs we have commenced with the calendar day on which the eggs were deposited and included the day on which hatching occurred. In computing the total effective temperature required for molting we have commenced with the day following dropping and included the day upon which molting took place. The above periods have been used in determining the mean temperatures. In reckoning the effective temperature where the daily mean does not fall below 43° F. the average daily mean for the period covered may first be obtained; then, by subtracting 43° F. (the "zero" of effective temperature) from this mean and multiplying the product by the number of days covered, the total effective temperature can be readily calculated. Since the monthly mean temperature must first be obtained, by following this method much time may be saved in calculating the total effective temperature. Where the mean temperature for one or more days during a given period falls below the "zero" of effective temperature (43° F.), the effective temperature for each day should be obtained and added in computing the total effective temperature. Our records on the incubation of eggs are based largely upon lots kept in glass tubes on sand.

RECKONING PERIODS.

In determining periods it has been the practice to commence with the day following dropping or hatching of the tick and to include the day oviposition commenced, molting occurred, or death took place, as the case might be. In calculating the period of incubation the day of oviposition as well as the day of hatching has been included, as in the case of the determination of effective temperatures.

In the life-history work in the laboratory it was the daily practice between the hours of 3 and 5 p. m. to separate the eggs from the females,[1] the molted ticks from those not molted, and to note the hatching of eggs. In case more eggs had been deposited than could be counted within this period, they were isolated in pill boxes and counted the following day. After the eggs were counted they were placed on sand in tubes. Thus the records of egg counts, moltings, and other life changes, as recorded in the tables here given, are for periods of about 24 hours.

In determining the periods of attachment, when these records have been made by the utilization of the bovine scrotum, it has been the practice to place the larvæ, nymphs, or adults in a cotton bag secured to the host. The bag was examined at periods of 10 to 12 hours and attachment noted. Ticks still in the bag at the end of 24 hours were usually removed. In some cases, however, ticks have been kept in the bag for longer periods, but attention is called to these cases where they occur. Some ticks have been found to remain upon the host for several days unattached or without attaching securely. This might or might not occur naturally, but must be taken into consideration. Where small mammals were employed for the engorgement of ticks, in most cases the individuals were examined at frequent intervals, so that the time of attachment was noted rather accurately.

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[1] In determining the number of eggs deposited by a species only females that have been permitted to drop should be used.

This class of animals was usually allowed to remain in the attachment cages for 5 or 6 hours, specimens not attached at the end of that time being returned to rearing tubes.

REARING TICKS.

In rearing ticks one of the first considerations is to eliminate, so far as possible, the danger to the experimenter of infection by disease-bearing species. This requires great care in manipulation, and complete isolation, by water and grease or some other substance, of all specimens likely to be infected.

Although it is desirable that the usual host be used in determining the parasitic periods, so that variations from the normal condition may be eliminated, this was not always possible. In a few instances small wild mammals which were captured in nature have been utilized for the rearing of ticks and the study of their habits. Animals which have become infested in nature may often be successfully employed in the study of the habits of the ticks with which they are infested. Most of the species which we have studied attach to domestic animals, and as nearly all of these attach to a bovine, we have largely made use of this host in determining the parasitic periods and habits of the species. The method found most satisfactory is that suggested by Prof. C. P. Lounsbury, of attaching a bag over the scrotum of a bovine. In this way the various stages of ticks were applied, examinations made, and the ticks removed as they dropped, and comparatively few were lost. All of the ixodids, except certain species of Ixodes, thus applied by the writers, have attached in one or more stages. Some species, *Dermacentor variabilis* in particular, attach with considerable reluctance. By removing the bag and with it the unattached ticks at the end of a given period and then replacing the bag and making examinations twice daily and removing the engorged ticks from it, the exact periods of engorgement were determined. In order to prevent the removal of the bag from the scrotum by the host a harness has been employed in some instances and in others leather or wire muzzles have been found satisfactory (Plate I). With the ticks which pass both molts upon the host, as do *Margaropus annulatus*, *Dermacentor nitens*, *D. albipictus*, and *O. megnini*, it is a comparatively easy matter to follow the life cycles, but with those which drop from the host to molt, as is the case with most of our North American species, it is much more of a task. With those species which drop for each molt one must succeed in getting the same individuals to attach to the host and catch them as they drop three or more different times. After dropping each time they must be isolated under favorable conditions and frequent examinations made to determine the periods of molting and ovipositing. In order to present satisfactory information upon these periods the periods must be recorded in connection with the thermometric readings, as all life processes when the ticks are off the host appear to be affected by variations in temperature. Our out-of-doors records are based upon temperatures registered by the thermograph shown in Plate II, figure 1. Those indoors were based on a similar thermograph kept in the room with the ticks and regulated by standard thermometers.

In determining the life cycle of ticks that attach to small animals, such as dogs, rabbits, squirrels, fowls, and others, a satisfactory arrangement found has been the use of a cage made of wire of about ¼-inch mesh, permitting the ticks to drop through into a pan beneath. (See Pl. I, fig. 4.) This cage, made with a wooden frame, should have the joints set in white lead or putty in order to eliminate all possible hiding places into which the ticks might crawl for protection. Nails inserted in the frame serve as posts, preventing the ticks from crawling back to the cage. In the pan or tray under the cage may be placed strips of paper, beneath which the ticks will crawl. Some thick and absorbent paper, such as blotting paper or pressing paper, should be placed in the bottom of the tray or pan to absorb the urine. When this is used it is not necessary to eliminate succulent food from the diet of the host animal. It has been the practice to place a ring of white axle grease about the rim of the pan or tray to prevent the escape of any of the ticks which have dropped. Another and more satisfactory way of preventing their escape is by setting this pan or tray in a larger one filled with water. When the examinations are made the tray can be removed, the ticks collected, and the cage cleaned with little difficulty. The plan of this tray was first suggested to the writers by Prof. Lounsbury and is similar to that which he has used. A more satisfactory cage than the one just described for use with small hosts, such as guinea pigs and rabbits, has been made by taking two wire desk trays or baskets and fastening them with rubber bands, one bottom side up over the other, as shown in Plate I, figure 1. The principal advantage of this kind of cage over the other is that places for hiding are practically eliminated, thereby allowing quicker examinations. Though the cages may be made of other coarse-mesh wire screen, the desk trays are to be preferred. To prevent the animals from shaking the ticks across the moat an 18-mesh wire-screen band is placed around the cage, with its base set in the tray and the top extending a few inches higher than the cage.

In order to keep the ticks upon or near the host while attaching and to prevent their escape, a canvas cage was used. A square wooden frame was first made, to which the canvas was fitted just tight enough to permit of the removal of the frame so that the canvas bag could be inverted and readily cleaned.

It has been found that certain small animals used as hosts for breeding ticks learn after a few infestations to keep up a constant fight against ticks. This habit necessitates special attachment cages and also great care to prevent the ticks from being scratched off after they are once attached. A number of different forms of attachment cages have been devised. The utility of these varies with the individual animal used as a host as well as the species of host and species and stage of ticks applied. In some instances it has been found that successful attachments may be secured by placing the host and ticks in a close-fitting, loose-woven cotton bag with the end tied up. Another method of keeping the host quiet while the parasite is allowed to attach is to put the animal in a cylinder of 4-mesh wire. The cylinder should be large enough to be comfortable, but not large enough to allow the animal to turn around. In some cases a rectangular piece of 4-mesh wire is bent into the shape of a V-formed trough about 2½ inches on each side and 5 or 6 inches long. This trough-shaped piece is inverted and placed over the back of the animal within the cylinder, the front end being drawn down tightly over the head to prevent shaking. The cylinder containing the animal is then placed in an inverted bell jar in a pan surrounded by a moat. (See Pl. I, fig. 2.) The animal is kept in this cage only for a sufficient time to allow the ticks to attach. Small animals which do not fight the ticks may be placed in an inverted bell jar over a moat without using the cylinder. The bell jar should be covered with coarse-mesh screen held down by rubber bands stretched down on different sides to the handle of the jar.

In order to determine the parasitic period of *Ornithodoros megnini*, cotton bags were fastened about the ears of the host animal and held in place by tying the puckering strings to rings in a cord fastened about the horns, as shown in Plate I, figure 5.

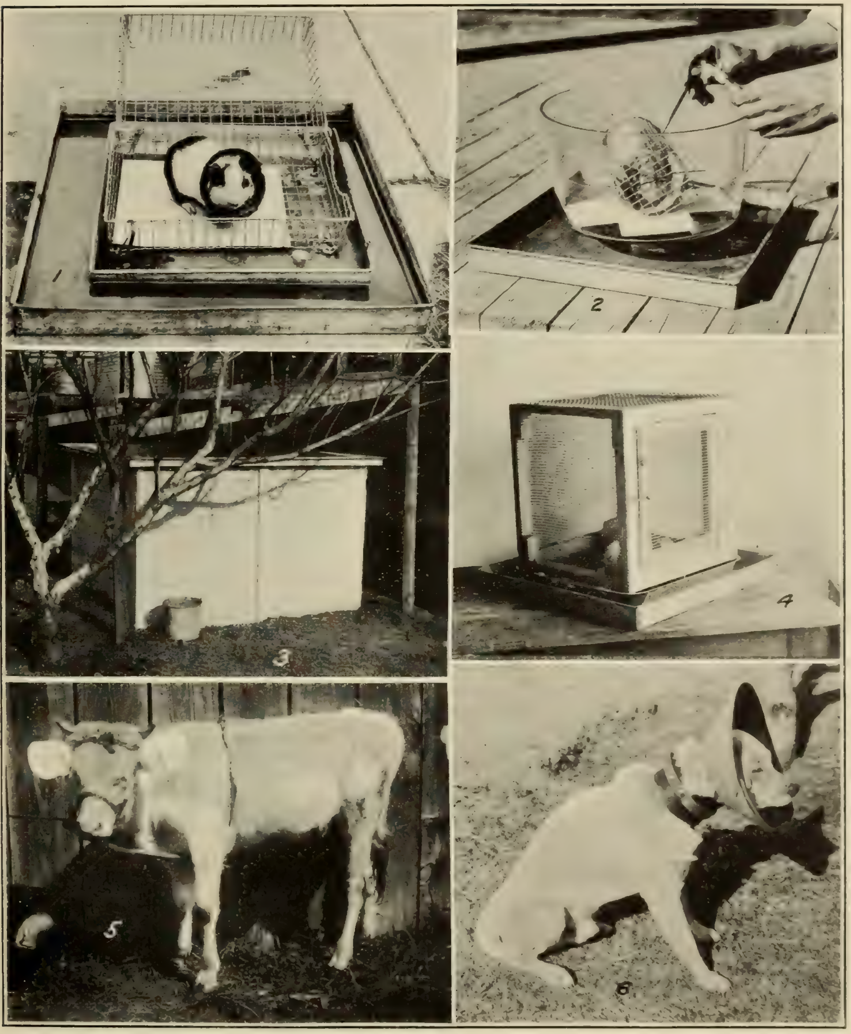
In engorging nymphs and adults of *Argas miniatus*, it has been found necessary to place a hood about the fowl's head in order to prevent it from devouring the ticks. Our experience has shown it to be necessary to bind the legs of the fowl sufficiently close together, with a strip of cotton cloth, to prevent an attempt at removing the hood and possible strangulation. Neither the hood of cheesecloth nor the cord, if properly applied, will occasion undue restlessness if the fowl is accustomed to handling.

In applying ticks to tortoises it is necessary to tie a bag about the shell behind the front legs, as otherwise the ticks are likely to be devoured.

While some ticks attach immediately after being placed upon a host, others wander about for some time before attaching, and with some species only part will attach, even though kept for several days in the bag attached to the host. In the observations here recorded those that had not attached at the end of 24 hours were removed from the bag. Others that might not have attached but that were upon the host were permitted to remain. Thus the observations reported actually indicate what takes place in nature.

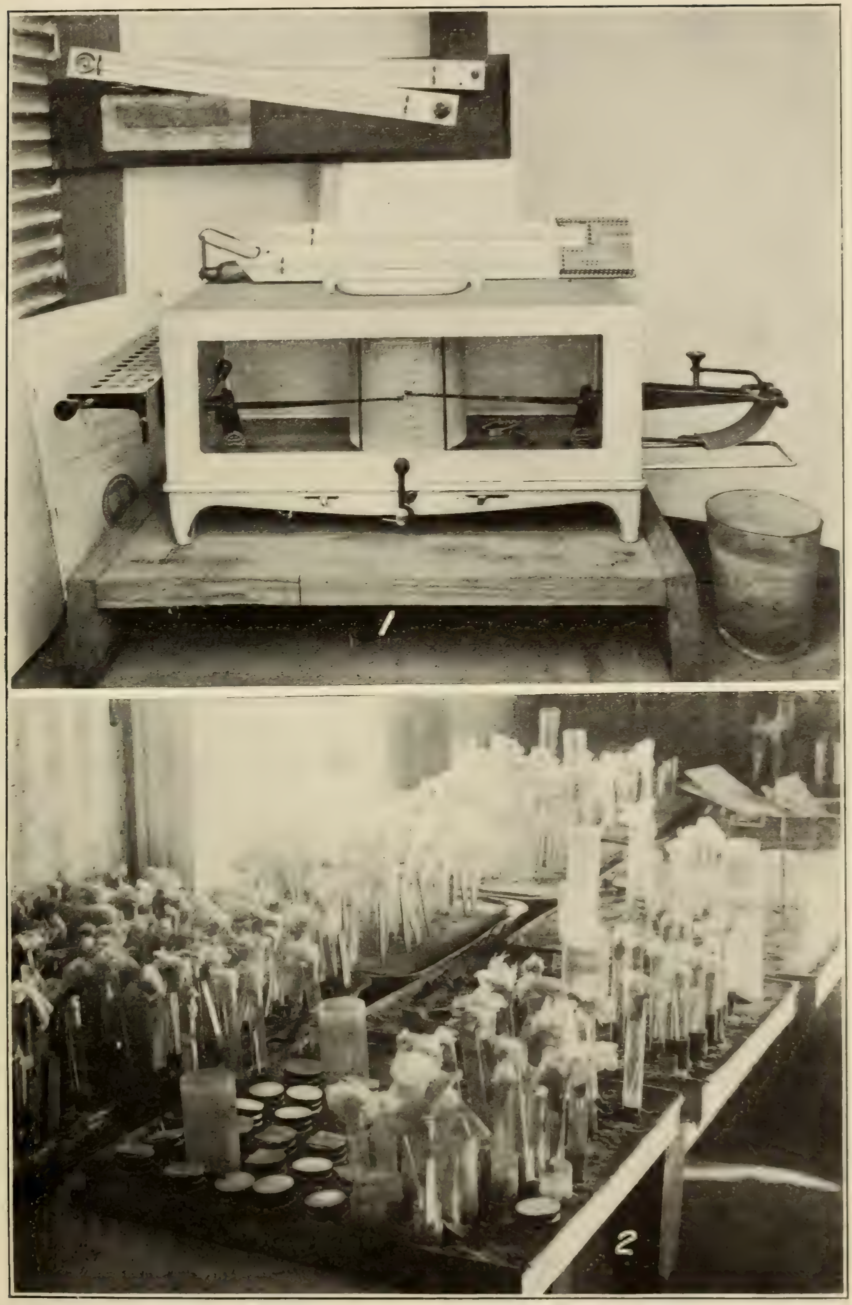
In a few instances rabbits, guinea pigs, and fox squirrels have allowed ticks to become engorged when no provision was made to prevent the host from scratching. Usually, however, special precautions must be taken to prevent the host from displacing the parasites. With most of the small animals, a leather collar has been successfully utilized. These collars are made by cutting out a disk-shaped piece of leather with a hole in the center slightly larger than the neck of the animal. The width of the collar should be at least equal to the distance from the neck to the chin. In applying the collar the ends are lapped and fastened with brass rivets. By keeping the outer edge of the collar circular, the disk takes the form of a truncated cone with base extending forward around the head. (See Pl. I, fig. 6.) When dogs are used, a leather band 4 or 5 inches wide should be placed around the neck behind the other collar so as to keep it forward. In order to protect ticks attached on the ears of rabbits, a disk-shaped collar made of light boards is employed. This collar should be made in two parts, the halves being fastened together with rubber bands so as to permit of removing the collar easily and to make it flexible.

As the engorged ticks are removed from the bag or tray, it has been found that favorable conditions for further development are furnished by placing them in pill boxes upon moist sand. These pill boxes are prepared by puncturing the tops and bottoms, or still better, they are furnished with gauze tops, to permit of free circulation. Still more favorable conditions are furnished by inserting sand in test tubes from which the bottoms have been removed. The bottoms of tubes may be removed in a satisfactory manner by plunging the tubes into cold water after they have been heated by friction produced by rubbing with a string wrapped around the tube at the point where the cut is desired. These tubes should always be used with those species which, in the immature stages, have a habit of burrowing into the sand before becoming quiescent. As stoppers for the tubes, absorbent cotton will largely prevent too humid an atmosphere, if protected from rains. A large tray, as shown in Plate II, figure 2, has been used filled with sand into which the tubes have been inserted and on which the pill boxes have been kept. By subirrigation the amount of moisture furnished can be kept nearly constant without interfering with the pill boxes. This subirrigation is best furnished by use of a large glass tube extending to the bottom of the sand; water poured into this will gradually percolate through and moisten the entire surface. In most of our



APPARATUS AND CONTRIVANCES USED IN LIFE-HISTORY STUDIES OF TICKS.

Fig. 1.—Rearing cage. Fig. 2.—Bell jar containing attachment cylinder and animal. Fig. 3.—Outdoor attachment and engorgement box. Fig. 4.—Dropping cage. Fig. 5.—Bull with harness. Fig. 6.—Dog with collar. (Original.)



APPARATUS USED IN LIFE-HISTORY STUDIES OF TICKS.

Fig. 1.—Thermograph and apparatus for weather records. Fig. 2.—Pans with glass tubes and pill boxes, in and on moist sand. (Original.)

longevity experiments in the laboratory we have used test tubes with the bottoms removed and placed in trays with moistened sand. The mouths of the tubes are closed with absorbent cotton. Observations can readily be made through the glass without disturbing the ticks and the air in the tube is kept moderately humid. For longevity experiments out of doors, we have made use of 1½-inch glass tubing cut in lengths of about 10 inches. In one end of these tubes about 2 inches of moist sand and clay is firmly packed to prevent the escape of the ticks through the bottom. These tubes are then set in galvanized-iron cylinders which are sunk into the soil. The soil from the inside of the cylinder is removed to a sufficient depth to allow the surface of the dirt in the tube to be on a level with the surrounding earth. In place of an absorbent cotton stopper a piece of bleached cotton was firmly tied over the top with rough cord, which would stand prolonged exposure without breaking. If exposed to rains but largely protected from the sun during the warmer months the longevity can be determined under normal but favorable conditions. The above methods have also been employed in obtaining preoviposition and oviposition records. Most of the longevity records here reported are based on tube experiments, but in work with *Margaropus annulatus* we have also placed engorged females collected within 24-hour periods in clumps of grass, about which screen cages were set to prevent intrusion, and determined the longevity by recording the dates seed ticks first appeared upon the grass and the dates the last could be found.[1]

NATURAL CONTROL.

CLIMATIC CONDITIONS.[2]

Cold appears to be the most effective check upon the spread of some species, while heat and a small or an excessive rainfall are equally effective with others. The effect of atmospheric humidity is undoubtedly an important factor also. Dr. Arnold Theiler (1908) has found the larvæ of *Margaropus annulatus decoloratus* to die within 30 minutes when exposed to a temperature of −5° C. (23° F.) for 48 hours, although they are not affected by an exposure to that temperature for 24 hours. We have found that with the cattle tick, engorged females kept in tubes without stoppers were killed at Dallas in October when the temperature fell to 13° F. for a few hours. Eggs of several species of ixodids have been found to be rendered nonviable by exposure to sun on bare ground for a few hours when the atmospheric temperature was about 101° F. The eggs of the ixodid ticks often fail to hatch when not supplied with moisture during periods of excessive heat in summer or during dry winters when the incubation period is very long. Flooding apparently has little influence in controlling ixodid ticks, as the larvæ of *M. annulatus* have been found by Hunter and Hooker (1907) to survive a submergence of from 10 to 157 days. Vorontzov (1907) states that the eggs of *Ixodes ricinus* may retain their vitality under water from fall to spring, and Hunter and Hooker have found the eggs of *M. annulatus*, when submerged, to hatch in about the normal period.

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[1] This can readily be done by running the bared hand and arm over the grass.

[2] The admirable studies of the cattle tick by Cotton and Voorhees (1911) have come to hand too late to note in this bulletin. Cotton reports that all adults of *M. annulatus* exposed at 14° F. were killed; that when unprotected all the larvæ are killed at 4° F. and all the eggs at 2°. It was found that when more than 25 per cent of the original weight of the eggs of this tick is lost they will not hatch.

PREDACEOUS ENEMIES.

Sowbugs, which have been supposed to destroy eggs of ticks, have been shown by Pierce (1907, pp. 17 and 22) to consume comparatively small numbers even when confined with no other source of food supply. *Solenopsis geminata*, an ant widely disseminated in this country, is thought to be an important enemy of ticks. Rats and mice feed upon ticks and field mice undoubtedly assist in a limited way in destroying the engorged females. Wellman (1906b) has observed a reduviid bug (*Reduvius* [*Opsicætus*] *personatus*) feeding on engorged ticks in Africa.

Domestic fowls have been found to destroy cattle ticks that drop about farm buildings and even to jump up and pick them off dairy cows. A hen has been observed by the writers to devour with avidity as many as 150 engorged females of *Margaropus annulatus* in a half day. Quite a number of species of birds have been observed to light on cattle and feed on the engorged ticks. Several species of blackbird, including the great-tailed grackle or "jackdaw" (*Megaquiscalus major macrourus*), bronzed grackle (*Quiscalus quiscula æneus*), and Brewer's blackbird (*Euphagus cyanocephalus*) are known to do so in Texas. Kingbirds (*Tyrannus tyrannus*) have been observed to do this in Louisiana, and Newstead (1909) reports that in Jamaica the savannah blackbird or tinkling grackle (*Quiscalus crassirostris*) and the ani or "parrot-billed blackbird" (*Crotophaga ani*) have the same habit. McAtee (1911a) states that Mr. H. S. Barber has observed red-eyed cowbirds (*Tangavius æneus involucratus*), boat-tailed grackles (*Megaquiscalus major*), and another species of blackbird picking ticks from cattle at Brownsville, Tex. At Tampico, Mexico, Bishopp observed the groove-billed ani (*Crotophaga sulcirostris*) to feed upon *Margaropus annulatus australis*, attached to cattle. This species and the red-winged blackbird (*Agelaius phœniceus*) are said by Moreau (1907, figs. 8–9) to prey upon cattle ticks in Mexico. Cherry (1892, p. 325) states that the groove-billed ani habitually feeds upon cattle ticks in Costa Rica. Bendire (1895, p. 435) states that eastern cowbirds (*Molothrus ater*) and McAtee (1911b, p. 401) says that the fish crow (*Corvus ossifragus*) eat ticks. Other birds in the stomachs of which the Biological Survey of this department has found ticks (McAtee, 1911a) are the killdeer (*Oxyechus vociferus*), upland plover (*Bartramia longicauda*), meadowlark (*Sturnella magna*), dwarf hermit thrush (*Hylocichla guttata nana*), and house wren (*Troglodytes ædon*). Mr. J. D. Mitchell states that it is the habit of jackdaws to search for and destroy many cattle ticks on the range by inverting the dried dung, which furnishes a favorable protective covering for this tick. Pycraft has called attention (1910, p. 124) to a depraved habit that such birds may develop, citing the tick bird which occurs in Africa as an example:

> Take, for example, the case of the oxpecker or rhinoceros bird (*Buphaga africanus*), a native of South Africa and generally regarded as a species of starling. This bird is commonly found in intimate association with basking herds of cattle and big game, running about all over the bodies of these creatures in its search for the ticks and other parasites which harbor there. Lately, however, this bird has fallen into disgrace, since it has extended its attentions to the horses and cattle of the colonists with anything but happy results. It would seem that in removing ticks from the more tender hides of these animals the birds caused wounds, and at the same time gained a taste for blood, with the result that, where horses and cattle are at all numerous, they become severely persecuted by these birds, who now seek not so much to prey upon the ticks as the hosts thereof, which suffer considerably in consequence. Thus we see how easily long-rooted habits may become changed, and how an originally useful instinct may become depraved. The tough hide of the rhinoceros was proof against the beaks of these birds, and consequently nothing but good resulted from their presence, but, as we have shown, a very different state of things began when the hides of the imported domesticated animals became subjected to a similar inspection. On account of the damage they do the restrictions imposed by Government for their protection have now been removed, but the oxpecker will doubtless long contrive to hold his own in this vast country. The work of the rhinoceros bird in England is performed by the common starling and so far no harm to cattle has been done by reason of injuries inflicted on the hides. Similarly, in East Africa, egrets swarm over the bodies of elephants when they approach the neighborhood of water, apparently, as it has been suggested, for the sake of capturing the various kinds of insects put up by the elephants as they move about.

PARASITES.

Two chalcidoid parasites have been found to attack engorged nymphs. The first of the two, described by Dr. L. O. Howard in 1907 as *Ixodiphagus texanus*, was reared by Hooker from specimens of engorged nymphs of *Hæmaphysalis leporis-palustris* collected by Mr. J. D. Mitchell from rabbits in Jackson County, Tex. The extent of the parasitism and importance have not been determined. Nymphs subsequently collected in that locality were not parasitized.

The second parasite (*Hunterellus hookeri*) was described by Dr. Howard in 1908 from specimens reared by Hooker from engorged nymphs of *Rhipicephalus sanguineus*, collected by Wood from dogs at Corpus Christi, Tex. This species has been found to play an important part in destroying the brown dog tick in southern Texas. As specimens of this latter species have since been reared by Mr. C. W.

Howard in Mozambique, it will probably be found to be a widespread insect.

In addition to serving as intermediate hosts for various species of protozoa of the genera Piroplasma, Anaplasma, and Spirochæta, they apparently play the same rôle for filariæ, as has been reported by Grassi and Calandruccio (1890), Noe (1908), Baldasseroni (1909), Darling (1910), and Smith (1910).

IMMUNE RACE OF CATTLE.

Cattle with Brahman blood appear to be largely resistant to the attack of ticks. According to Borden (1910) this quality persists in animals with one sixty-fourth of Brahman blood. For this reason and the fact that they do not contract splenetic fever a large number have been imported into this country for breeding purposes in the South.

In regard to these cattle, Mohler and Thompson (1911) state that—

> The sebum secreted by the sebaceous glands of the skin has a peculiar odor which seems to be repugnant to insect life. The hide, while it may be as thin as in our domestic animals, still appears to be much tougher and is more difficult to penetrate with a hypodermic needle. The hair is quite short and does not provide favorable shelter for the development of ticks. These three factors are probably responsible for the slight amount of tick molestation which these animals experience.

In our native cattle a considerable individual variation in the susceptibility to tick attack is seen in the same breed of animals. The length of the hair and condition of the skin of the host seem to be the principal factors influencing tick attack.

ARTIFICIAL CONTROL.

Ticks may be controlled by picking or brushing them from the host and destroying them, by smearing or spraying the host with a disinfectant solution, or by dipping the host in a vat which contains a solution sufficiently strong to kill the ticks and not injure the host. For the details relating to these methods reference should be made to bulletins by Mohler (1905, 1906), Graybill (1909), and Hunter and Bishopp (1911b).

The method by which the cattle tick may be eradicated through a rotation (starvation) system suited to the farm or by a combination of rotation and dipping is also described in the bulletins of Mohler and Graybill above mentioned. Additional information will be found in bulletins by Newell and Dougherty (1906), Hunter and Hooker (1907), Cotton (1908), Hunter and Mitchell (1909), and others. Control methods are briefly considered under the several species.

Restriction of the dissemination of some species may be brought about through quarantining the hosts, as has been done with the cattle tick in this country.

DEVELOPMENT OF THE ARGASIDÆ.

The first of the two families of ticks, the Argasidæ, is represented in the United States by 2 genera and 6 described species. We have studied a representative of each of the genera.[1]

All of the argasids so far as known, with one exception, pass their molts off the host. The larvæ of species belonging to the genus Argas that have been studied remain attached to the host for several days while engorging, but the nymphs and adults require only a few hours at most to engorge. The nymphs molt two or three times, following as many engorgements. The adults engorge repeatedly, each engorgement being followed by oviposition. Unlike other species of the genus thus far studied, *Ornithodoros megnini* engorges and passes the first molt upon the host; as a nymph it remains attached to the host for a long period, then drops, molts, is fertilized, and oviposits without engorging as an adult, shortly after the completion of which it dies. So far as known it is the only species of tick that does not engorge in the adult stage. Two species of Ornithodoros (*savignyi* and *moubata*) are known to pass the larval molt before feeding, the latter molting the larval skin while still in the egg.

The periods of oviposition, incubation, and molting vary with the temperature; for this reason temperature records have been included in the tables. With the exception of *Ornithodoros megnini*, the females of the species known engorge and oviposit repeatedly. The longevity of some of the species, particularly those of the genus Argas, is quite remarkable, as is shown in the following table:

TABLE III.—*Maximum longevity recorded for ticks of the family Argasidæ.*

Species.	Maximum longevity of stages.[2]			
	Larva	Nymph, first stage	Nymph, second stage.	Adult.
	Days.	*Days.*	*Days.*	*Days.*
Argas miniatus	164	269	445	880
Ornithodoros megnini	80	....	....	638+

Genus ARGAS Latreille.

Six well-established and 4 doubtful species are included in the genus Argas by Nuttall and Warburton in their monograph of the Argasidæ, *miniatus* being placed as a synonym of *persicus*. In addition to *miniatus*, which we have studied, only one other species, *brevipes*, is known to occur in the United States, although *Argas reflexus* has been erroneously reported as occurring here. Several of the species, particularly *miniatus* and *reflexus*, are the source of great loss to poultry keepers, due to the removal by them of blood from the fowls, and more particularly because of the transmission by them of spirochetosis.

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[1] Two other species of Ornithodoros (*O. talaje* and *O. turicata*) are being studied.

[2] Longevity of third nymphal stage of *A. miniatus* not determined.

The species are nocturnal parasites of chickens, geese, pigeons, and other birds and occasionally attack mammals. They remain hidden away by day in cracks and crevices, coming out at night from their hiding places to find the fowl host and engorge with blood.

The life history and habits of *Argas miniatus*[1] as worked out by Lounsbury in South Africa are practically identical with those of *miniatus* as determined by the writers. This tick has been shown to be the active agent in the transmission of the causative organisms of spirochetoses (*Spirochæta gallinarum* and *S. anserinum*) of chickens, geese, and other fowls.

In the larval stage *Argas miniatus* remains upon the host for several days to engorge, but in the nymphal and adult stages only a few hours at most are required. In *miniatus*, the only species of Argas whose life history has been followed, there is a second, and in about one-seventh of the individuals a third nymphal molt, as has been shown by Hooker (1909*c*). As adults, repeated engorgement takes place, each nearly always followed by the deposition of eggs.

THE FOWL TICK.

Argas miniatus Koch.

The common name, fowl tick, is derived from the fact that this species feeds almost exclusively on domestic fowls and is an important enemy of them.

DESCRIPTIVE.

Adult (Pl. III, figs. 5–8).—Males, unengorged, 4.5 by 3.5 mm. to 6 by 4.5 mm.; engorged, 5.5 by 3.5 by 2 mm. to 7 by 4 by 2.25 mm. Females, unengorged, 5 by 3 mm. to 8.5 by 5.33 mm.; engorged, 6 by 4 by 2 mm. to 12 by 7 by 3 mm.

Nymph (Pl. III, figs. 2–4).—Last stages (2d and 3d nymphal): Unengorged, 3 by 2 mm. to 4 by 2.75 mm.; engorged, (premales) 5 by 3.5 by 2 mm. to 7 by 4 by 2 mm., (prefemales) 6 by 4 by 2 mm. to 8.5 by 5 by 2.5 mm. The normal brown color becomes purplish when blood is engorged. First stage: Unengorged, 2 by 1.25 mm. to 2.5 by 1.5 mm.; engorged, 3 by 2 by 1 mm. to 4 by 3 by 1 mm. Brown, the margins of the body and legs colorless.

Larva (Pl. III, fig. 1).—Unengorged, about 0.8 by 0.6 mm., pale yellow to colorless; engorged, 2.2 by 1.5 mm. to 2.5 by 2 mm., dark blue. In one instance a larva dropped on the fourth night following attachment, and before assuming the flattened Argas shape.

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[1] We have thought best to refer to the American fowl tick as *A. miniatus;* recent investigations, however, indicate that it is synonymous with *A. persicus,* the name of the Old World fowl tick.

This individual, after assuming the flattened shape, measured only 1.5 by 1 mm.

Egg.—The average size of 10 eggs measured was 0.72 by 0.65 mm. Spherical, dark brown, shining, smooth.

HOST RELATIONSHIP.

This tick is principally a parasite of poultry. A single larva was collected by Mr. J. D. Mitchell on a meadowlark in southern Texas, and Mr. F. C. Pratt found a few larvæ on a wild turkey at Sabinal, Tex. That it may occasionally be found upon mammals and possibly engorge upon and be disseminated by them is shown by the fact that three adults were removed by Mr. J. D. Mitchell from a jack rabbit shot in Maverick County, Tex., in May, 1906.

Lounsbury has found *Argas miniatus* in South Africa commonly to attack geese, ducks, and turkeys, and he states that it has been reported to attack canaries and ostriches. It is well known in Persia as the Miana bug. Nuttall and Warburton found this tick to engorge on rats and mice, but with difficulty.

In the larval stage these ticks remain attached to the host for several days before dropping fully engorged, but in the nymphal stages and as adults they engorge in a comparatively short time, a few hours at the most, and nearly always at night. The larvæ appear to prefer the portions of the body where the feathers are sparse, particularly beneath and on the underside of the wings.

Larvæ placed in a bag on the scrotum of a bovine and left for 24 hours failed to attach. An attempt to engorge larvæ on pigeons was also unsuccessful. On one occasion a single individual of a number of adults applied to a guinea pig attached and became partially engorged.

GEOGRAPHICAL DISTRIBUTION.

(Fig. 1.)

This tick was originally described by Koch from Demarara. In this country (see fig. 1) it has been found to be a very common species in certain sections of southern Texas, and appears to be so at certain points in Florida, New Mexico, Arizona, and California. The Marx collection contains specimens from Iowa. It is very probable that this and other records of the occurrence of this tick in the Central States are based upon specimens introduced into that region, the infestation being only temporary. A careful study of the normal distribution of the species in Texas shows that the limit of its eastern range practically coincides with the division between the Lower Sonoran and Austroriparian faunas. It is widely disseminated in the tropical regions of the New World, having been reported from Mexico, Panama, Jamaica, Cuba, Barbados, Antigua, Martinique, Trinidad, Colombia, British Guiana, and Brazil. It is also found in many parts of Africa, Asia, Europe, and Australia.

LIFE HISTORY.

Observations on the life history and habits of *Argas miniatus* have been reported by Fuller (1896), Brown (1902), Lounsbury (1903a), Hunter and Hooker (1907), Nuttall and Warburton (1908), Hooker (1908, 1909), Galli Valerio (1909), Rohr (1909), and others.

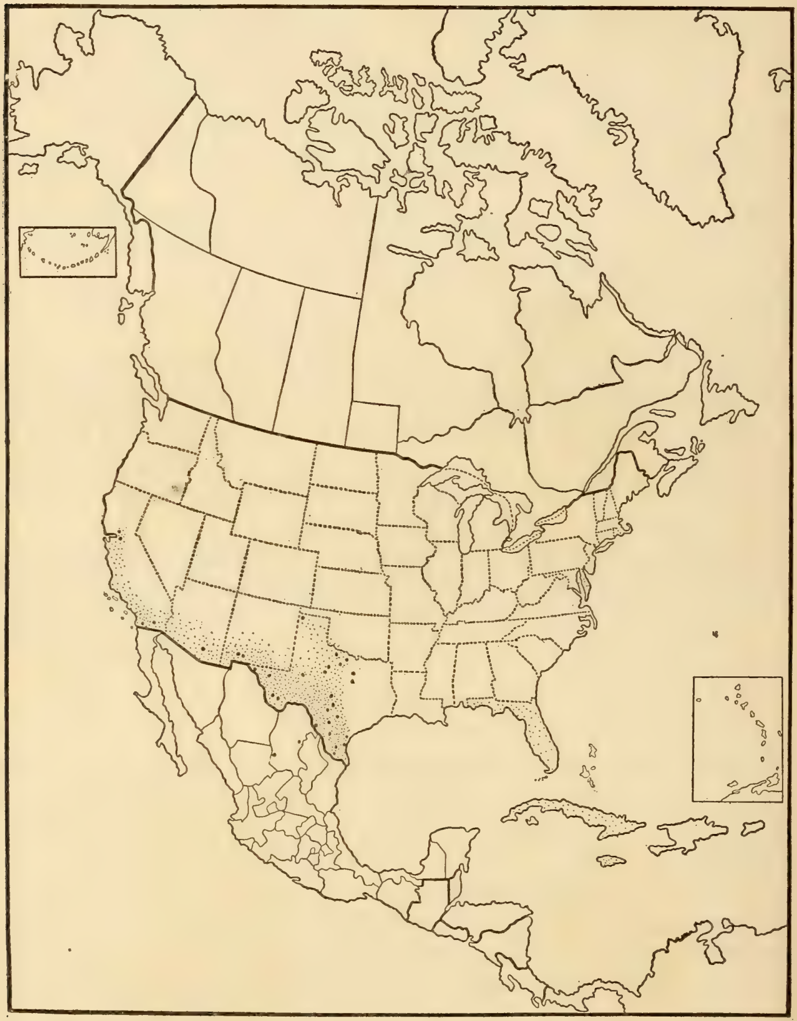
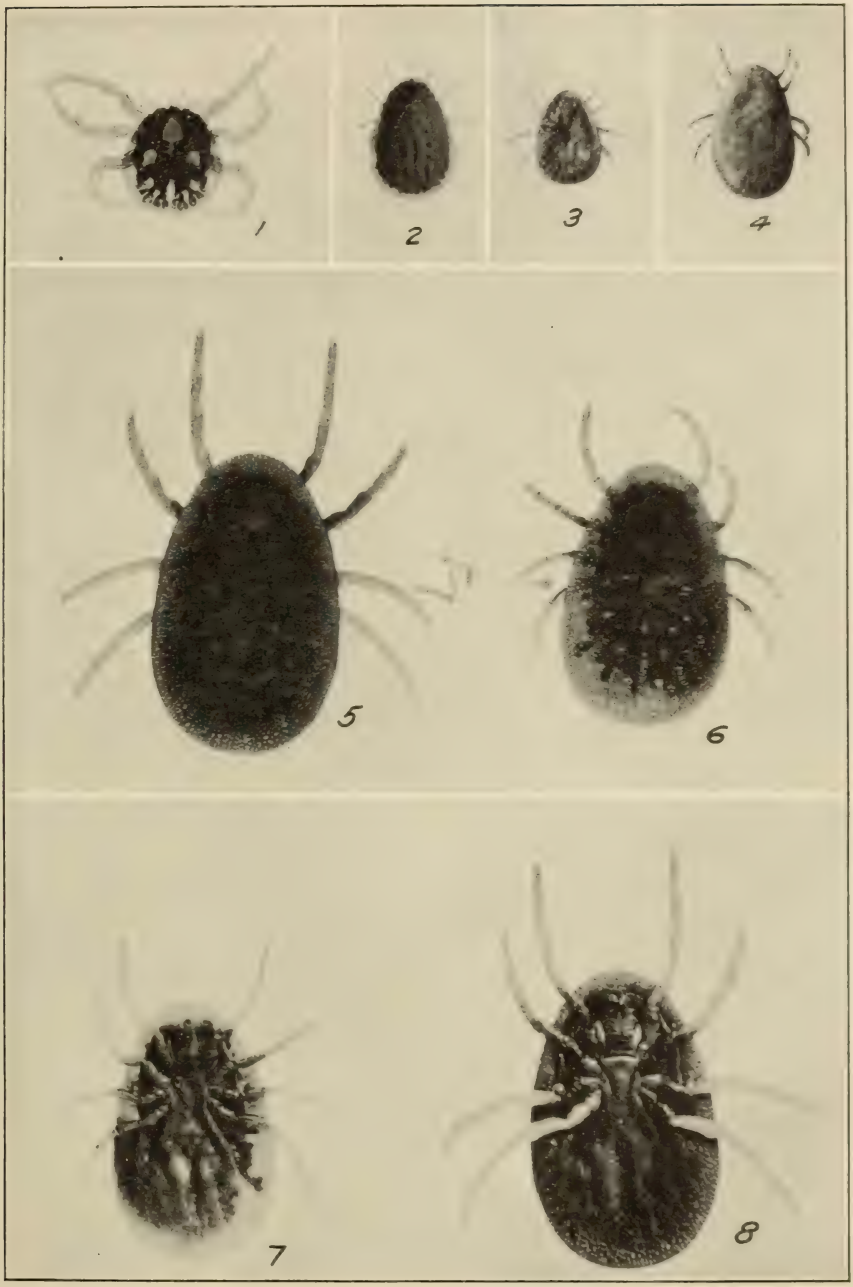


FIG. 1.—The fowl tick, *Argas miniatus:* Distribution in the United States and in part of the West Indies. The large dots show localities where the species has been collected in our investigation. The small dots indicate the probable range of the tick. (Original.)

The egg (Tables IV and V).—At summer temperatures at Dallas, Tex., following the first and third engorgements as adults, eggs were deposited as soon as the third day, while after the second engorge-



THE FOWL TICK, ARGAS MINIATUS.

Fig. 1.—Unengorged larva. Fig. 2.—Unengorged nymph after first molt. Fig. 3.—Unengorged nymph after second molt. Fig. 4.—Engorged nymph after second molt. Fig. 5.—Engorged female, dorsal view. Fig. 6.—Unengorged male, dorsal view. Fig. 7.—Unengorged male, ventral view. Fig. 8.—Engorged female, ventral view. (Original.)

ment eggs were deposited as soon as the second day. In several instances ticks did not oviposit until they had fed a second time. When this occurred in the summer it is thought to have been due to the fact that they had not mated, as females which remained for several weeks after engorging without depositing eggs commenced to do so very shortly after being placed with males. In the winter, however, in some cases females when with males remained for long periods without depositing, but when fed a second time began deposition. During these long preoviposition periods the females flattened considerably, the blood evidently being used by the tick to sustain life rather than in the production of eggs.

As is shown in Table IV, the greatest number of eggs deposited by any of 21 ticks observed following the first engorgement as adults was 195. The greatest number deposited by any of 21 ticks observed following the second engorgement was 237, and the greatest number deposited by a single tick following the two engorgements, 401. Following the third engorgement 245 was the largest number of eggs deposited by any of the 21 ticks observed. The greatest number of eggs deposited by any one tick following the first three engorgements was 646. The greatest number of eggs deposited by any one of the 20 ticks which were observed following the fourth engorgement was 228. Nine ticks deposited following the fifth engorgement, the greatest number of eggs deposited by an individual being 201. Although four ticks engorged the sixth time only two of these oviposited. One of these deposited 43 and the other 148 eggs. Only one tick engorged and deposited the seventh time, 47 eggs being deposited. The largest number of eggs deposited by any individual during its entire life was 874, the average number of eggs deposited per tick by the individuals observed being 537. The tick which deposited the largest number of eggs engorged five times and deposited four lots of eggs. The number of eggs deposited by any individual seems, in most cases, to be directly in proportion to its size. The average number of eggs deposited by an individual after each engorgement, based on those that oviposited, is as follows: First, 131; second, 159; third, 133; fourth, 110; fifth, 97; sixth, 95; seventh, 47. In observations previously recorded by Hunter and Hooker (1907) 274 eggs were deposited following a single engorgement. This record was based upon a tick which was adult when collected. The largest number of eggs deposited after a single engorgement by any individual observed by us was 237.

As is shown in Table IV, oviposition at summer temperatures may commence as soon as the third day after engorgement, or may be delayed for weeks if mating has not taken place. In the greater number of cases, however, it took place in from 4 to 10 days. Although the period of oviposition in one instance in which only a few eggs were deposited lasted only three days, it usually continues during the summer months for from 6 to 10 days. After the fourth deposition, engorgement of the ticks became more difficult with each succeeding deposition. This seemed to be due largely to the weakened condition of the ticks. It therefore appears that in nature ticks seldom engorge and deposit more than five times. It seems probable, however, that if the first engorgement were made early in the spring and the ticks were engorged as soon as possible after deposition was complete, a greater number of annual depositions would occur and probably the total number of depositions would be increased.

TABLE IV.—*Oviposition of Argas miniatus.*

Date nymph molted to adult.	Date of first engorgement.	First oviposition.	
		Dates.	Number of eggs.
1. June, 1908	June 21, 22, 1908	June 29–July 10, 1908	125
2. June, 1908	do	June 28–July 7, 1908	134
3. June–July, 1908	July 31–Aug. 1, 1908	Aug. 28–Sept. 1, 1908	49
4. July, 1908	July 27, 28, 1908	Did not deposit	
5. July 7, 1908	do	July 31–Aug. 8, 1908	135
6. July 4, 1908	July 29, 30, 1908	Aug. 3, 10, 1908	145
7. July, 1908	July 31–Aug. 1, 1908	Aug. 6–12, 1908	131
8. July 7, 1908	July 27, 28, 1908	Did not deposit	
9. July, 1908	do	Aug. 6–9, 1908	56
10. July, 1908	July 29, 30, 1908	Aug. 11–13, 1908	7
11. July 7, 1908	July 27, 28, 1908	Aug. 1–7, 1908	174
12. July 4–10, 1908	July 29, 30, 1908	Aug. 28–Sept. 3, 1908	101
13. Apr. 22, 1908	July 31–Aug. 1, 1908	Aug. 5–11, 1908	127
14. Aug. 15, 1908	Sept. 1, 2, 1908	Sept. 7–13, 1908	161
15. August, 1908	Aug. 27, 28, 1908	Sept. 2–8, 1908	195
16. ——, 1908	do	Sept. 2–9, 1908	151
17. June 15–July 15, 1908	July 31–Aug. 1, 1908	Sept. 9–15, 1908	154
18. Aug. 17, 1908	Sept. 3, 4, 1908	Sept. 9–16, 1908	151
19. ——, 1908	Aug. 27, 28, 1908	Sept. 3–10, 1908	144
20. ——, 1908	do	Sept. 2–9, 1908	176
21. ——, 1908	do	do	165

Date nymph molted to adult.	Date of second engorgement.	Second oviposition.	
		Dates.	Number of eggs.
1. June, 1908	July 29, 30, 1908	Aug. 8–13, 1908	81
2. June, 1908	July 31–Aug. 1, 1908	Aug. 5–11, 1908	111
3. June–July, 1908	Sept. 3, 4, 1908	Sept. 7–14, 1908	146
4. July, 1908	Aug. 21, 22, 1908	Sept. 10–17, 1908	83
5. July 7, 1908	Aug. 14, 15, 1908	Aug. 18–27, 1908	170
6. July 4, 1908	do	Aug. 18–25, 1908	172
7. July, 1908	Aug. 21, 22, 1908	Aug. 27–Sept. 2, 1908	154
8. July 7, 1908	Aug. 25, 26, 1908	Sept. 15, 1908	156
9. July, 1908	Aug. 14, 15, 1908	Aug. 20–28, 1908	137
10. July, 1908	Aug. 21, 22, 1908	Aug. 28–Sept 5, 1908	137
11. July 7, 1908	Aug. 14, 15, 1908	Aug. 18–27, 1908	227
12. July 4–10, 1908	Sept. 7, 8, 1908	Sept. 12–15, 1908	167
13. Apr. 22, 1908	Aug. 14, 15, 1908	Aug. 17–28, 1908	163
14. Aug. 15, 1908	Sept. 14, 15, 1908	Sept. 20–Oct. 4, 1908	219
15. August, 1908	Sept. 11, 12, 1908	Sept. 16–24, 1908	193
16. ——, 1908	do	Sept. 15–22, 1908	89
17. June 15–July 15, 1908	Sept. 20, 21, 1908	Sept. 26–Oct. 14, 1908	195
18. Aug. 17, 1908	do	Sept. 25–Oct. 19, 1908	237
19. ——, 1908	Sept. 14, 15, 1908	Sept. 20–Oct. 3, 1908	181
20. ——, 1908	Sept. 11, 12, 1908	Oct. 8–22, 1908	145
21. ——, 1908	do	Sept. 16–24, 1908	182

TABLE IV.—*Oviposition of Argas miniatus*—Continued.

Date nymph molted to adult.	Date of third engorgement.	Third oviposition.	
		Dates.	Number of eggs.
1. June, 1908	Aug. 14, 15, 1908	Aug. 17-24, 1908	111
2. June, 1908	do	Aug. 18-26, 1908	163
3. June-July, 1908	do	Sept. 20-27, 1908	153
4. July, 1908	Sept. 20, 21, 1908	Sept. 25-Oct. 8, 1908	116
5. July 7, 1908	Aug. 30, 31, 1908	Sept. 3-12, 1908	172
6. July 4, 1908	do	Sept. 4-10, 1908	160
7. July, 1908	Sept. 3, 4, 1908	Sept. 7-14, 1908	243
8. July 7, 1908	Sept. 27, 28, 1908	Oct. 14-19, 1908	76
9. July, 1908	Aug. 30, 31, 1908	Sept. 7-14, 1908	139
10. July, 1908	Sept. 7, 8, 1908	Sept. 13-15, 1908	122
11. July 7, 1908	Aug. 30, 31, 1908	Sept. 3-11, 1908	245
12. July 4-10, 1908	Sept. 21, 22, 1908	Sept. 26-Oct. 8, 1908	177
13. Apr. 22, 1908	Aug. 30, 31, 1908	Sept. 5-11, 1908	50
14. Aug. 15, 1908	Oct. 5, 6, 1908	Oct. 15-Nov. 9, 1908	227
15. August, 1908	Sept. 28, 29, 1908	Feb. 19-March, 1909	118
16. ——, 1908	do	Oct. 4, 1908	4
17. June 15-July 15, 1908	Oct. 27, 28, 1908	Nov. 14?-Dec. 11, 1908	149
18. Aug. 17, 1908	do	Did not deposit	
19. ——, 1908	Oct. 5, 6, 1908	Mar. 15-Apr. 5, 1909	102
20. ——, 1908	Oct. 29, 30, 1908	Mar. 2-21, 1909	25
21. ——, 1908	Sept. 27, 28, 1908	Oct. 6-20, 1908	106

Date nymph molted to adult.	Date of fourth engorgement.	Fourth oviposition.	
		Dates.	Number of eggs.
1. June, 1908	Aug. 30, 31, 1908	Sept. 8-15, 1908	97
2. June, 1908	Sept, 1, 2, 1908	Sept. 7-13, 1908	126
3. June-July, 1908	Oct. 6-8, 1908	Feb. 23-Mar. 20, 1909	90
4. July, 1908	Oct. 27, 28, 1908	Feb. ?-23, 1909	72
5. July 7, 1908	Sept. 14, 15, 1908	Sept. 20-Oct. 5, 1908	82
6. July 4, 1908	Sept. 11, 12, 1908	Sept. 17-25, 1908	167
7. July, 1908	Sept. 21, 22, 1908	Sept. 27-Oct. 17, 1908	182
8. July 7, 1908	Did not engorge		
9. July, 1908	Sept. 14, 15, 1908	Sept. 18-Oct. 6, 1908	81
10. July, 1908	Sept. 28, 29, 1908	Oct. 8-22, 1908	114
11. July 7, 1908	Sept. 14, 15, 1908	Sept. 19-30, 1908	228
12. July 4-10, 1908	Oct. 27, 28, 1908	Feb. 21-Mar. 6, 1909	72
13. Apr. 22, 1908	Sept. 14, 15, 1908	Sept. 19, 20, 1908	11
14. Aug. 15, 1908	Dec. 5, 6, 1908	Did not deposit	
15. August, 1908	Apr. 16, 17, 1909	Apr. 26-May 9, 1909	176
16. ——, 1908	Oct. 27, 28, 1908	Did not deposit	
18. Aug. 17, 1908	June 8, 9, 1909	Died June 20, 1909	
19. ——, 1908	Apr. 16, 17, 1909	Apr. 24-May 24, 1909	60
20. ——, 1908	June 8, 9, 1909	Did not deposit	
21. ——, 1908	Oct. 28, 29, 1908	Feb. 2-Mar. 8, 1909	97

TABLE IV.—*Oviposition of Argas miniatus*—Continued.

Date nymph molted to adult.	Date of fifth engorgement.	Fifth oviposition.	
		Dates.	Number of eggs.
1. June, 1908	Sept. 20, 21, 1908	Sept. 25–Oct. 17, 1908	135
2. June, 1908	Sept. 14, 15, 1908	Sept. 23–Oct. 17, 1908	61
3. June–July, 1908	Apr. 22, 23, 1909	May 11–16, 1909	72
4. July, 1908	Apr. 16, 17, 1909	May 5–14, 1909	85
5. July 7, 1908	Oct. 27, 28, 1908		
6. July 4, 1908	Sept. 27, 28, 1908	Apr. 5, 1909	11
7. July, 1908	Oct. 27, 28, 1908	Did not deposit	
8. July 7, 1908	Did not engorge	Crushed Apr. 24, 1909	
9. July, 1908	Oct. 27, 28, 1908	Did not deposit	
10. July, 1908	do	Lost	
11. July 7, 1908	Did not engorge		
12. July 4–10, 1908	Apr. 16, 17, 1909	Apr. 24–May 14, 1909	155
13. Apr. 22, 1908	Oct. 6, 7, 1908	Did not deposit	
14. Aug. 15, 1908	June 12, 13, 1909	June 21–27, 1909	114
16. ——, 1908	Aug. 25, 26, 1909		
19. ——, 1908	Aug. 24, 25, 1909	Aug. 20–Sept. 4, 1909	201
20. ——, 1908	Oct. 28, 29, 1909	Did not deposit	
21. ——, 1908	Sept. 16, 17, 1909	Apr. 28–May 12, 1909	41

Date nymph molted to adult.	Date of sixth engorgement.	Sixth oviposition.	
		Dates.	Number of eggs.
2. June, 1908	Oct. 27, 28, 1908	Died July 13, 1909	
3. June–July, 1908	Did not engorge	Died July 15, 1909	
4. July, 1908		Died July 13, 1909	
5. July 7, 1908	Oct. 28, 29, 1908	Killed Dec. 5, 1908	
6. July 4, 1908	Did not engorge	Died June 13, 1909	
7. July, 1908	Nov. 19, 20, 1909	Did not deposit	
11. July 7, 1908	Did not engorge, Oct. 27, 28, 1908.	Died Nov. 21, 1908	
14. Aug. 15, 1908		Died Aug. 23, 1909	
16. ——, 1908		Died Feb. 20, 1910	
19. ——, 1908	Sept. 20, 21, 1909	Oct. 2–5, 1909	43
21. ——, 1908	Aug. 25, 26, 1909	Aug. ?–Sept. 6, 1909	148

Date nymph molted to adult.	Date of seventh engorgement, or death of tick.	Seventh oviposition.		Total.		
		Dates.	Number of eggs.	Number of engorgements.	Number of depositions.	Number of eggs.
1. June, 1908	Died Oct. 28, 1908			5	5	549
2. June, 1908	Died July 13, 1909			6	5	595
3. June–July, 1908	Died July 15, 1909			5	5	510
4. July, 1908	Died July 13, 1909			5	4	356
5. July 7, 1908	Killed Dec. 5, 1908			6	4	559
6. July 4, 1908	Died June 13, 1909			5	5	655
7. July, 1908	Died Dec. 10, 1909			6	4	710
8. July 7, 1908	Crushed Apr. 24, 1909			5	2	252
9. July, 1908	Lost June 10, 1909			5	4	413
10. July, 1908	Lost			5	4	380
11. July 7, 1908	Died Nov. 21, 1908			5	4	874
12. July 4–10, 1908	Died before Aug. 4, 1909			5	5	672
13. Apr. 22, 1908	Died July 13, 1909			5	4	351
14. Aug. 15, 1908	Died Aug. 23, 1909			5	4	721
15. August, 1908	Died July 16, 1909			4	4	682
16. ——, 1908	Died Feb. 20, 1910			5	3	244
17. June 15–July 15, 1908	Died Jan. 5, 1909			3	3	498
18. Aug. 17, 1908	Died June 20, 1909			4	2	388
19. ——, 1908	Mar. 8, 9, 1910	Did not deposit [1]		7	6	731
20. ——, 1908	Died Mar. 30, 1910			5	3	346
21. ——, 1908	Sept. 20, 21, 1909	Oct. 2–8, 1909 [2]	47	7	7	786

[1] Died Apr. 4, 1910.

[2] Died Dec. 10, 1909.

The period required for the incubation of eggs in August was found to be as short as 10 days, at least 437° F. of effective temperature being required for incubation. Eggs kept in an incubator at a mean temperature of 89.8° F. hatched on the ninth day, an effective temperature of 421° F. accumulating. Rohr states that eggs kept at 35° C. (95° F.) hatch in from 8 to 11 days.

TABLE V.—*Incubation period of Argas miniatus.*

Eggs deposited.	Hatching.	Minimum incubation period.	Temperature during incubation.			
			Maximum.	Minimum.	Average daily mean.	Total effective.
		Days.	*° F.*	*° F.*	*° F.*	*° F.*
June 29, 1908	July 11, 1908	13	93.5	70.5	81.44	499.75
July 1, 1908	July 14, 1908	14	93.5	70.5	81.98	545.75
July 9, 1908	July 21, 1908	13	94.0	74.0	83.79	530.25
July 31, 1908	Aug. 12, 1908	13	99.0	73.0	86.15	561.00
Aug. 5, 1908	Aug. 15, 1908	11	99.0	73.0	86.59	479.50
Aug. 7, 1908	Aug. 16, 1908	10	99.0	73.0	86.75	437.50
Aug. 10, 1908	Aug. 19, 1908	10	96.5	75.0	87.15	441.50
Aug. 18, 1908	Aug. 30, 1908	13	93.0	75.5	85.48	552.25
Aug. 24, 1908	Sept. 5, 1908	13	94.5	75.0	83.40	525.25
Aug. 31, 1908	Sept. 11, 1908	12	97.5	74.5	84.41	496.95
Sept. 3, 1908	Sept. 15, 1908	13	97.5	74.5	83.49	526.45
Sept. 30, 1908	Oct. 28, 1908	29	87.0	48.0	69.00	755.00
Oct. 7, 1908	Nov. 15, 1908	40	87.0	34.0	65.29	887.00
Oct. 8, 1908	Nov. 7, 1908	31	87.0	45.0	67.00	743.00
Nov. 7, 1908	Jan. 22, 1909	77	82.0	17.0	59.50	1.141.00+
Nov. 9, 1908	Feb. 23, 1909	107	85.0	17.0	59.50	1.582.00+
Nov. 23, 1908	...do	93	85.0	17.0	58.50	1.339.00+
May 1, 1909	May 20, 1909	20	95.0	51.0	70.50	671.00
Sept. 20, 1909	Oct. 15, 1909	26	95.0	52.0	74.50	860.00
Oct. 2, 1909	Oct. 24, 1909	23	94.0	52.0	73.10	693.00
Oct. 6, 1909	Nov. 3, 1909	29	92.0	51.0	71.00	831.00

The larva (Tables VI, VII, VIII).—Seed ticks kept in pill boxes in the laboratory at an average daily mean temperature of 61.9° F. have been found to live as long as 164 days. During midsummer the longevity is about two months.

TABLE VI.—*Larval longevity of Argas miniatus.*

Date hatching began.	Date all larvæ dead.	Days from hatching to death.	Date hatching began.	Date all larvæ dead.	Days from hatching to death.
Aug. 9, 1908	Oct. 20, 1908	62	Nov. 2, 1908	Mar. 22, 1909	140
Sept. 8, 1908	Dec. 25, 1908	108	Nov. 9, 1908	Mar. 27, 1909	137
Sept. 25, 1908	Jan. 24, 1909	121	Dec. 1, 1908	Mar. 17, 1909	105
Oct. 15, 1908	Feb. 24, 1909	132	May 18, 1909	July 15, 1909	77
Oct. 17, 1908	Mar. 30, 1909	164	May 24, 1909	July 27, 1909	64
Oct. 21, 1908	Mar. 27, 1909	147			

At a temperature varying from 18° C. (64.4° F.) to 27° C. (80.6° F.) Rohr has found individual larvæ to live as long as 65 days.

Ordinarily larvæ do not commence to drop from the host until the fourth day following attachment, although one may occasionally leave the host a day sooner. All the larvæ which we observed engorged and left the host by the tenth day following attachment. The observations of Rohr (1909) on the dropping of the larvæ do not agree exactly with ours. According to his records in Brazil the larvæ may commence to drop as soon as the second day following attachment, the greater number leaving the host on the third and fourth days and all leaving the host before the eighth day.

TABLE VII.—*Engorgement of larvæ of Argas miniatus.*

Date larvæ were applied.	Number of larvæ dropped engorged—days following attachment.[1]								Total number dropped.
	3½	4	5	6	7	8	9	10	
Aug. 12, 1907, 5.00 p. m.	0	0	17	12	4	1	0	0	34
Aug. 19, 1907, 5.00 p. m.	0	1	9	6	4	1	0	0	21
Oct. 13, 1907, 11.00 a. m.	0	0	0	1	1	0	0	0	2
June 30, 1908, 8.00 p. m.	0	0	0	48	14	2	0	0	64
Aug. 22, 1908, 10.00 p. m.	0	0	18	12	2	0	0	0	32
Sept. 20, 1909, 10.30 p. m.	1	36	17	19	14	5	2	1	95
Do	0	17	4	3	3	0	0	0	27
Oct. 22, 1909, 10.00 p. m.	0	0	0	12	17	10	9	2	50

[1] In this and all subsequent tables in which this arrangement is followed, the top line of figures represents the number of days following attachment or dropping and the figures in the columns beneath represent the number of ticks dropped, the number molted, or the number of eggs deposited on the respective days following attachment or dropping as the case may be.

In a test to determine the relative susceptibility of individual fowls to tick attack, a Leghorn pullet, a Barred Plymouth Rock pullet, a setting hen (part Leghorn) and a sick hen (part Leghorn) were placed in a cage and infested with larvæ. An effort was made to place about the same number of larvæ on each individual and a number were left free in the cage with the fowls. The following number of ticks dropped from the different individuals: Leghorn pullet 26, Plymouth Rock pullet 27, setting hen 95, and sick hen 13. The sick hen died on the sixth day after infestation. A second infestation of the three remaining fowls was made on a later date. At this time the setting hen was no longer inclined to set. As a result of this infestation, about the same number of larvæ were engorged on each of the three fowls. The experiment tends to indicate that there is no marked variation in the susceptibility of individuals of different breeds. It appears to show, however, that on setting hens, which are quiet at the time of infestation and afterwards, the number of larvæ which develop is greatly increased.

Up to within a few hours of dropping, the larvæ are globular in shape, but at this time they flatten and assume the typical Argas shape, which permits the tick to crawl rapidly and secrete itself before being discovered and devoured by its natural enemies. Barring accident the engorged larvæ drop only at night when their host is upon the roost. The larval is the only stage in which the species remains upon the host for any length of time. Advantage can be taken of this fact in preventing its dissemination.

Seed ticks have been observed to gather on the ventral surface of adult ticks and it is thought possible that they are at times assisted in finding hosts by clinging to the older ones.

In August at a mean temperature of 83° F. molting commenced as soon as the fourth day, an effective temperature of 160° F. being required. In one case a molting period of 32 days was observed. In this instance the individual was undoubtedly very weak as it did not succeed in freeing itself from the exuvium without assistance. Rohr states that with a temperature of 35° C. (95° F.) molting takes place in 4 or 5 days.

TABLE VIII.—*Molting of larvæ (first ecdysis) of Argas miniatus.*

Date engorged larvæ dropped—night of.	Number.	Larvæ molted—days following dropping.															Temperature from dropping to date first tick molted.		
		4	5	6	7	8	9	10	11	12	13	14	16	17	32	Number molted.	Maximum.	Minimum.	Average daily mean.
																	°F.	*°F.*	*°F.*
Aug. 16, 17, 1907	14	0	10	1	0	0	0	1	0	0	0	0	0	0	0	12	......	......	....
Aug. 17, 18, 1907	10	0	5	3	0	0	0	0	0	0	0	0	0	0	0	8	......	......	....
Aug. 18, 19, 1907	4	1	0	1	0	1	0	0	0	0	0	0	0	0	0	3	......	......	....
Aug. 23, 24, 1907	9	0	2	4	2	0	0	0	0	0	0	0	0	0	0	8	......	......	....
Aug. 24, 25, 1907	6	0	3	0	0	0	0	0	0	0	0	0	0	0	0	3	......	......	....
Oct. 19, 20, 1907	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	......	......	....
Apr. 23, 24, 1908	2	0	0	0	0	0	0	0	0	1	0	1	0	0	0	2	83.0	47.0	67.90
July 5, 6, 1908	48	0	31	5	4	1	0	2	0	0	0	0	0	0	0	43	93.0	75.5	83.00
July 6, 7, 1908	14	1	8	3	0	0	0	0	0	0	0	0	0	0	0	12	93.0	75.5	83.00
July 7, 8, 1908	2	0	1	0	0	0	1	0	0	0	0	0	0	0	0	2	93.5	75.5	83.79
Aug. 26, 27, 1908	16	0	4	3	4	0	0	0	0	0	0	0	0	0	0	11	89.5	75.5	83.29
Aug. 27, 28, 1908	12	0	11	1	0	0	0	0	0	0	0	0	0	0	0	12	89.5	75.5	83.29
Aug. 28, 29, 1908	2	0	1	0	0	0	1	0	0	0	0	0	0	0	0	2	89.5	75.5	83.42
Sept. 24, 25, 1909	70	0	0	0	0	3	36	10	1	0	0	0	0	0	0	50	91.0	56.0	72.9
Sept. 25, 26, 1909	33	0	0	0	0	8	19	3	0	0	0	0	0	0	0	30	92.0	56.0	73.7
Sept. 26, 27, 1909	28	0	0	0	3	14	1	3	1	0	0	0	0	0	1	23	92.0	56.0	74.1
Sept. 27, 28, 1909	20	0	0	4	12	4	0	0	0	0	0	0	0	0	0	20	92.0	56.0	75.0
Oct. 27, 28, 1909	37	0	0	0	0	0	0	12	14	7	0	2	0	0	0	35	84.5	55.0	72.5
Oct. 28, 29, 1909	32	0	0	0	0	0	3	14	10	0	0	0	0	2	0	29	84.0	55.0	71.8
Oct. 29, 30, 1909	10	0	0	0	0	0	0	5	0	3	2	0	0	0	0	10	84.0	55.0	71.7
Total	370	...	...	...	...	...	...	...	...	...	...	...	...	...	...	316	......	......	....

The nymph (Table IX).—Rohr shows that at a mean temperature of 15° C. (59° F.) first and second stage nymphs may live as long as two years, while at a temperature varying from 17° C. (62.6° F.) to 33° C. (91.4° F.) all under observation were dead in 469 days.

This species appears to vary in the number of molts that it passes as a nymph. As previously shown by Hooker (1909), there is a third nymphal molt in many of the individuals which have been reared. In view of the fact that the extra molt could not be traced to a difference in the sexes, the food supply, or the climatic conditions, it is thought that it might have been due to an adaptation that the species is undergoing, as the fourth ecdysis requires an extra engorgement before reproduction can commence. The nymphs, like the adults, require only a comparatively few minutes for engorgement.

Nuttall and Warburton found that two-thirds of the nymphs and adults engorged within 30 minutes. In observations of 148 nymphs these workers found 120 minutes to be the longest period required for engorgement.

First-stage nymph (Table IX).—The longevity of first-stage nymphs was found in one instance to be as great as 269 days. Of 29 first-stage nymphs, which molted between July 28 and 31, 1907, and were kept in pill boxes, 14 were found to be alive on October 12, 5 having escaped and 12 being dead. Of the 14 remaining alive 3 escaped, the others succumbing as follows: Two on November 14, 1 on November 21, 1 on January 1, 1 on February 18, 3 between March 27 and April 16, and the last one on April 25, 1908. A large number of first-stage nymphs which molted from larvæ October 3–8, 1909, were all dead by April 22, 1910, thus living slightly over 6 months. The greatest longevity recorded in a lot of 88 first-stage nymphs which molted from larvæ November 7–12, 1909, was slightly over 9 months.

TABLE NO. IX.—*Molting of nymphal stages of Argas miniatus.*

[♂=Male. ♀=Female. ⊕=Nymph.]

MOLTING OF FIRST STAGE (SECOND ECDYSIS).

Date engorged first-stage nymphs dropped.	Number.	First-stage nymphs molted—days following dropping (engorgement).																		Temperature from dropping to date first tick molted.		
		7	8	9	10	11	12	13	14	15	16	17	20	23	24	25	26	28	Number molted.	Maximum.	Minimum.	Average daily mean.
																				°F.	°F	°F.
Aug. 28, 29, 1907	11	0	2	2	5	1	1	0	0	0	0	0	0	0	0	0	0	0	11	......	......	......
Sept. 1, 2, 1907	10	0	2	1	2	2	3	0	0	0	0	0	0	0	0	0	0	0	10	......	......	......
Apr. 23, 24, 1908	......	0	0	0	0	0	0	0	0	0	0	0	2	2	1	1	4	1	11	86.0	47.0	69.3
May 20, 21, 1908	......	0	0	0	0	2	4	4	3	1	1	3	0	0	0	0	0	0	18	86.0	68.0	77.5
July 20, 21, 1908	37	18	13	0	4	0	1	0	0	0	0	1	0	0	0	0	0	0	37	95.0	76.5	84.6

MOLTING OF SECOND STAGE (THIRD ECDYSIS)

Date second-stage nymphs engorged.	Number.	Second-stage nymphs molted—days following dropping (engorgement).																
		11	12	13	14	15	16	17	18	19	20	24	26	30	33	36	37	43
Oct. 3, 4, 1907	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Apr. 24, 25, 1908	......	0	0	0	0	0	0	0	0	0	0	0	1♀	1♂ 1♀	1♂	1♂	1	2♂
July 31, Aug. 1, 1908	......	3♂	3♂ 1♀	1♂ 5♀	1♂ 2♀	0	1♀	0	0	0	0	1♀	0	0	0	0	0	0
Aug. 4, 5, 1908	18	0	0	3⊕	1♂ 5♀	1♂ 1♀	1♂ 1♀	1♂ 1⊕	0 1♀	0 1♂	0	0	0	0	0	0	0	0
Aug. 6, 7, 1908	7	0	0	0	0	1⊕	3♂ 1♀	1♂	0	0	1♂	0	0	0	0	0	0	0

TABLE No. IX.—*Molting of nymphal stages of Argas miniatus*—Continued.

MOLTING OF SECOND STAGE (THIRD ECDYSIS)—Continued.

Date second-stage nymphs engorged.	Number.	Second-stage nymphs molted—days following dropping (engorgement).									Temperature from dropping to date first tick molted.		
		177	183	184	185	195	199	Number molted.			Maximum.	Minimum.	Average daily mean.
											°F.	°F.	°F.
Oct. 3, 4, 1907	9	1♂	2♀	1⊕	1⊕	1♂	0	2♂	2♀	2⊕	....	....	....
Apr. 24, 25, 1908	......	0	0	0	0	0	0	...	...	...	87.0	47.0	70.91
July 31, Aug. 1, 1908	......	0	0	0	0	0	0	8♂	10♀	0⊕	99.0	73.0	86.06
Aug. 4, 5, 1908	18	0	0	0	0	0	0	5♂	8♀	4⊕	99.0	73.0	86.61
Aug. 6, 7, 1908	7	0	0	0	0	0	0	5♂	1♀	1⊕	99.0	73.0	86.64

MOLTING OF THIRD STAGE (FOURTH ECDYSIS).

Date third-stage nymphs engorged.	Number.	Third-stage nymphs molted—days following dropping (engorgement).					Temperature from dropping to date first tick molted.		
		9	10	11	12	Number molted.	Maximum.	Minimum.	Average daily mean.
							°F.	°F.	°F.
June 20, 21, 1908	2	0	0	0	2♀	2	89.5	71.0	80.73
Aug. 28, 29, 1908	5	1♀	1♂	2♀	1♀	5	97.5	75.0	83.98

Observations are recorded by Nuttall and Warburton, who found all of 14 first-stage nymphs of this species to engorge and drop within 35 minutes.

Second-stage nymph (Table IX).—In our experiments second-stage nymphs lived longer than those in the first stage. Of two which molted July 31, 1907, and were kept in a pill box, one died July 30, 1908. One nymph which molted from the first stage on June 15, 1908, was still alive February 23, 1909, when it was lost, thus having a longevity of at least 253 days. The last individual of a large number of first-stage nymphs which molted to this stage October 24–31, 1909, died January 12, 1911, thus showing a longevity of 445 days. The last tick of a lot of 12 which molted from the first stage November 1, 1909, died March 25, 1911, having lived 509 days, or about 1 year and 5 months. At a mean temperature of 86° F. in August, nymphs of the second stage molted as soon as the eleventh day following engorgement, 473° F. of effective temperature being required.

Third-stage nymph (Table IX).—We have found that about one-seventh of the individuals reared under similar conditions pass a third nymphal molt—i. e., of 49 individuals reared from seed ticks to adults 7 passed a third nymphal molt. Six of these after molting proved to be females and one a male.

In August, at a mean temperature of 84° F., molting commenced as soon as the ninth day following dropping, an effective temperature of 369° F. being required.

The adult[1] (Table X).—The males and females may be readily distinguished by the shape of the genital orifice, that of the former being crescent shaped while in the latter it is merely a transverse slit.

The longevity of the adults is surprisingly great. From a lot of ticks collected March 24, 1906, which were kept confined in a vial with a cork stopper, one lived until September 3, 1907, a period of 17 months. In two miscellaneous lots of some 50 or more ticks collected May 12, 1906, and kept in large vials with paper strips, the last individual died about October 12, 1908, having lived for 2 years and 5 months. Some individuals in nearly all of a large number of lots of collected ticks have been found to live more than one year.

Females lived from 5 to 13 months when engorged soon after they had molted to the adult stage and immediately after each deposition. One specimen, which was engorged three times, lived 18 months, depositing 244 eggs in the meantime.

The longevity of adults which have not fed after molting appears to be slightly less than when some food has been taken. One individual, which molted to an adult August 16, 1908, was still alive May 27, 1910, having lived over 21½ months. However, most of the specimens observed died between 4 and 12 months after molting. Laboulbène (1881) has reported the fowl tick to live (unfed) for more than three years.

Fertilization is accomplished by means of a spermatophore, which is deposited by the male at the genital aperture of the female, following the introduction of the hypostome of the male into the genital opening of the female. The act of copulation is described in somewhat greater detail on page 30.

The adults engorge repeatedly and oviposition follows each engorgement, with few exceptions. Thus, as shown in Table IV, we have found females to engorge as many as seven times, each engorgement being followed by the deposition of eggs. Lounsbury (1903a) has found females to engorge as many as seven times and to deposit following six engorgements. As has been stated, Nuttall and Warburton found that two-thirds of the nymphs and adults engorge within 30 minutes. We have not determined the exact time required for engorgement. However, in one case 38 per cent of a large number of adults applied to a fowl had dropped engorged when examination was made an hour and a half later. Usually engorgement takes place at night, but when fowls are exposed to their attack in dark places, such as on nests, engorgement may take place during the daytime. In warm weather oviposition is usually completed in from 10 to 14 days and engorgement takes place again as soon as a host is found.

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[1] Our system of numbering adult ticks of this species, in order that they might readily be identified after engorging, consisted in the docking of a part of one or more legs. This apparently has no ill effect upon these ticks.

The dimensions of females prior to engorgement is increased slightly with each deposition. The average size of an individual taken after successive engorgements does not, however, seem to increase noticeably after the tick has become replete the second time. The size of males also appears to increase slightly with successive engorgements. The maximum, minimum, and average length, width, and thickness of females, the deposition of which is recorded in Table IV, before and after each engorgement, is given in Table X.

TABLE X.—*Size of females of Argas miniatus before and after successive engorgements.*

Number of engorgement.	Number of ticks measured.	Size before engorging.		
		Maximum.	Minimum.	Average.
		Mm.	*Mm.*	*Mm.*
First	9	7 by 5	5 by 3.5	6.4 by 4.1.
Second	11	7.5 by 4.75	6.5 by 3.75	7.1 by 4.4
Third	18	8 by 5.5	7 by 4	7.4 by 4.5.
Fourth	19	8 by 5.5	6.1 by 4.3	7.5 by 4.6.
Fifth	14	8.8 by 5.5 by 1.6	6.9 by 4.2 by 1.3	7.7 by 4.8 by 1.5.
Sixth	8	9.6 by 5.9 by 2.3	7 by 4.3 by 1.2	8.1 by 4.9 by 1.7.
Seventh	2	8.6 by 5.1 by 2.1	7.4 by 5.1 by 1.3	8 by 5.1 by 1.7 .

Number of engorgement.	Number of ticks measured.	Size after engorging.		
		Maximum.	Minimum.	Average.
		Mm.	*Mm.*	*Mm.*
First	19	10 by 6 by 3.5	6 by 4 by 2	8.8 by 5.4 by 2.7.
Second	20	10.5 by 6.5 by 3.5	8 by 5 by 2.5	9.5 by 5.6 by 2.9.
Third	21	11 by 6 by 3.5	8 by 4.2 by 2.25	9.6 by 5.6 by 2.7.
Fourth	17	11 by 6.5 by 3	8.5 by 4.5	9.4 by 5.5 by 2.6.
Fifth	14	10.3 by 6 by 2.7	8 by 4.7 by 1.9	9.2 by 5.5 by 2.5.
Sixth	4	10.2 by 6.5 by 3	9.4 by 5.7 by 2.4	9.8 by 5.9 by 2.9.
Seventh	2	9.9 by 5.9 by 2.6	9.3 by 5.5 by 3	9.6 by 5.7 by 2.8.

LIFE CYCLE.

This tick as a larva attaches to a fowl, preferably beneath the wings, remains attached usually for 5 or 6 days, becomes engorged, and, a few hours before dropping, flattens out and assumes the typical Argas shape. The larvæ drop at night, at a time when the fowl host is upon the roost and where they will be near the host when ready to engorge again. In summer a period of 4 or more days passes before the engorged larvæ molt and the 8-legged nymphs appear. The second engorgement, which occurs at night, lasts only a few hours at the most and is followed in summer by a period of 7 days or more before the second molt. A third engorgement occurs at night and 11 days or more pass before any of the ticks molt and appear as adults. In about one-seventh of the individuals there is an extra nymphal or fourth molt before arriving at the adult stage, 9 or more days (369° F. of effective temperature) being required for the ecdysis. The first adult engorgement then takes place, and following copulation eggs are deposited. Unlike the ticks of other genera, with the exception of some species of Ornithodoros, these ticks engorge a number of times as adults, and each engorgement is usually followed by oviposition. The eggs may hatch in summer as soon as 10 days, 437° F. of effective temperature being required for their incubation.

ECONOMIC IMPORTANCE.

In parts of the southern United States this tick is the most important ectoparasite of fowls, though perhaps surpassed in some localities by some of the insect pests. It is frequently referred to as the "blue bug" because of the bluish color when engorged with blood. In Brazil, Martinique, India, Soudan, Transcaucasia, and South Australia a disease of fowls known as spirochetosis is transmitted by this species. The presence of this disease in the United States has not been demonstrated, but on account of the losses due to the tick as a parasite in certain sections of Texas, poultry raisers in some cases have entirely abandoned the business. It has been found that the spirochete virus when imbibed will remain virulent within the tick during a period of six months fasting. Dodd (1910), who has recently studied the disease in Australia, reports that in one instance a fowl which was bitten by ticks that had fasted for 7 months and 6 days died with symptoms of chronic spirochetosis.

Lounsbury, who has permitted specimens of *Argas miniatus* and *Ornithodoros savignyi* to feed upon his arm, concludes that while they may be productive of considerable irritation and their penetration serve as the entering point for some of the abscess-forming bacteria, as may be said of all the ticks, yet otherwise their direct effect is harmless. Nuttall and Strickland (1908) have found that the salivary glands and intestines of the fowl tick contain anticoagulin, but no hemolysin.

NATURAL CONTROL.

The habits of this tick are such as to protect it from natural enemies, although it is undoubtedly fed upon by rats and mice and devoured by fowls. To determine the effect of water upon it, 25 larvæ which had hatched on September 1 were submerged on September 9 and kept so for 17½ hours, during all of which time they remained inactive. When removed from the water all proved to be alive and were again submerged and left until a total period of 65½ hours had elapsed. One survived and lived for about two weeks following removal from the water. Thirteen larvæ which had hatched several days previous were submerged on September 12 for a period of 50 hours and none survived.

ARTIFICIAL CONTROL.

It is not our intention to go into detail regarding remedial measures at this time, as a circular is being prepared from which the information may be obtained.

The larvæ, which may remain attached to the fowl as long as 8 days before dropping, are almost certain to be carried from one locality to another with the fowls. In order to prevent such dissemination, fowls should be isolated in a tick-free cage or inclosure for 10 days before being transported to a tick-free house, as by the end of the period all will have dropped from the fowl. As it is the habit of ticks to crawl into cracks and crevices, it should be borne in mind that they may be conveyed from one point to another in shipping cages unless great care is taken. It is thought quite probable that the larvæ may be disseminated by pigeons and small birds.

The species is resistant to insecticides to a remarkable degree. When once this tick has become established in a poultry house, it is difficult to eradicate it entirely except through the use of fire. Much, however, can be accomplished by the frequent use of kerosene, crude petroleum, or creosote. Frequent and thorough cleaning of the poultry house and the application of one of these substances to the cracks and crevices will greatly assist in keeping the pest down.

Several plans for roosts which will prevent the ticks from gaining access to fowls at night have been suggested by Lounsbury (1903a) and others. In practice it has been found that roosts and nests suspended from the roof with baling wire will largely protect the fowls from tick attack. It is also important that the ticks be furnished with the least number of hiding places possible.

Genus **ORNITHODOROS** Koch.

Only one of the four species of the genus Ornithodoros which occur in the United States has been studied.[1] This species, *Ornithodoros megnini*, appears to be the only one of the four that occurs in sufficient numbers to be of particular economic importance. Nuttall and Warburton in their monograph of the Argasidæ have recognized 11 well established and 3 doubtful species as belonging to the genus. One of these, *O. moubata*, is of special importance, as it transmits human tick fever in Africa.

THE SPINOSE EAR TICK.

Ornithodoros megnini (Dugès).

The common name of *Ornithodoros megnini* is taken from its habit of infesting the ears and from the characteristic spines on the body of the nymph.

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[1] As previously stated studies of two other species (*O. turicata* and *O. talaje*) are now under way.

DESCRIPTIVE.

Adult (Pl. IV, figs. 6–9).—Female 5 by 3.5 by 2.5 mm. to 10 by 6 by 3.5 mm. Male usually somewhat smaller than the female. The adults are grayish to dark brown in color.

Nymph (Pl. IV, figs. 2–5).—Unengorged, 2.25 by 1.5 mm. to 3 by 2 mm.; engorged, 7 by 4 by 2 mm. to 8 by 5 by 3 mm. The body of nymphs as they emerge from the larval skin have a blood-red color extending to the first two segments of the legs; otherwise they are a pearly white. Soon, however, they turn to a reddish brown.

Larva (Pl. IV, fig. 1).—Unengorged, about 0.55 by 0.30 mm.; engorged, 3 by 2 mm. to 4 by 2.5 mm. The seed ticks are dark gray in color, turning to a pink, then to a whitish color as they engorge.

Egg.—Spherical, dark brown, shining, smooth. The average size of 10 specimens measured was 0.480 by 0.456 mm.

HOST RELATIONSHIP.

It is the habit of this tick to attach in the ears of the host, deep down in the folds of the concha and frequently in the external meatus. This habit appears to be more or less of an adaptation for protection, since they can not be removed by the host, or picked off by birds, and are not exposed to the attack of parasites.

The species was described from specimens taken from the ears of Mexican horses. Though collected more frequently from cattle than from any other host, it appears to attach to any of the larger mammals with which it comes in contact. In collections made in Texas and neighboring States by agents of the Bureau of Entomology up to January, 1911, 53 lots were from cattle, 11 from horses, 10 from dogs, 8 from cats, 3 from asses, 2 from mules, 2 from man, and 1 each from sheep and hog. It has been taken by Mr. H. S. Barber in California from the black-tailed deer.

GEOGRAPHICAL DISTRIBUTION.

(Fig. 2.)

This tick was originally described by Dugès from Guanajuato, Mex., where it is said to be very abundant. We have found it to be a very important tick in certain parts of Texas, New Mexico, Arizona, California, and Mexico. Owing to the fact that it remains attached for long periods it may be widely disseminated on cattle, horses, and other animals shipped from an infested district. This fact doubtless accounts for some of the records from northern States. Up to the present time we have authentic records of its collection from the States of Kentucky, Iowa, Nebraska, Kansas, Oklahoma, Oregon, New Mexico, Idaho, Nevada, Arizona, California, Colorado, Texas, Louisiana, and Utah. The species was found in abundance by

Bishopp at Monclova, Durango, Torreon, Aguas Calientes, and Monterey, Mex. It is undoubtedly present throughout the greater part of Mexico and may be found to be distributed through Central and parts of South America when systematic collection is undertaken, as the Marx collection contains three lots with 15 well developed and 4 partially developed nymphs, which were taken from cattle in the Santa Lucia Mountains of Brazil. The accompanying map (fig. 2) shows approximately the normal range of the species in North America.

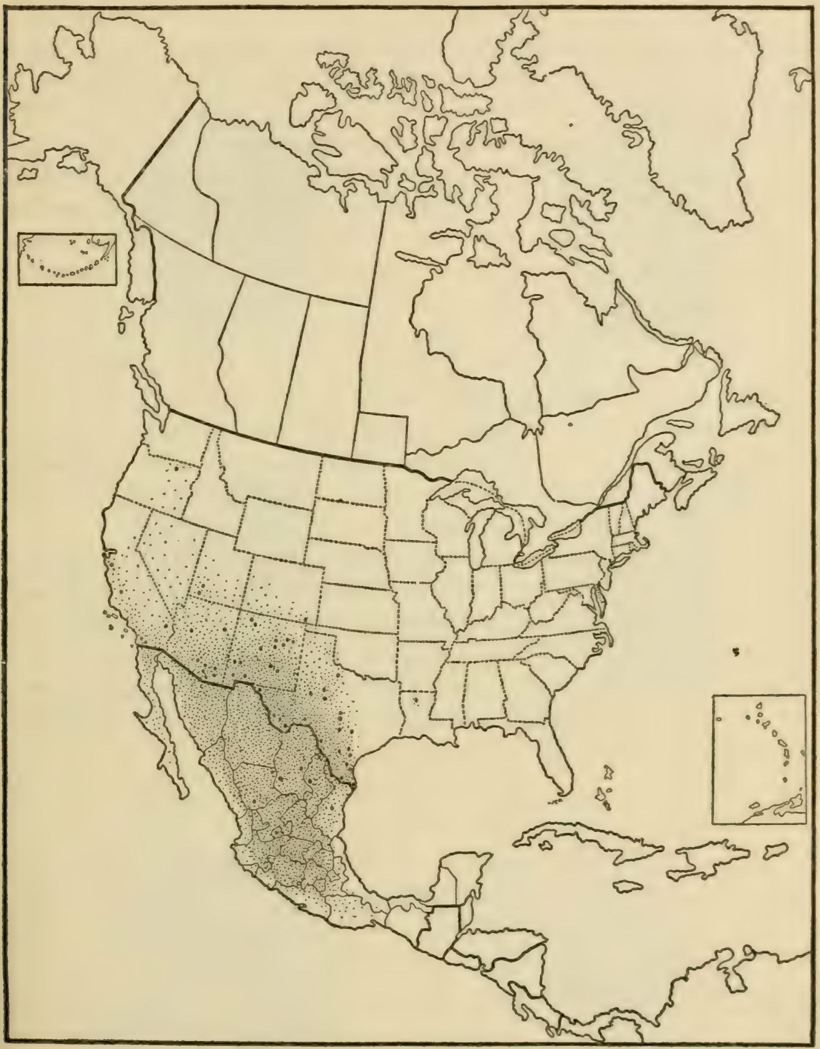


FIG. 2.—The spinose ear tick, *Ornithodoros megnini:* Distribution. The large dots show localities where the species has been collected in our investigation. The small dots show the probable range of the species. (Original.)

Although not recorded from Cuba, the species has probably been introduced there with cattle from the mainland, as large shipments of cattle from the infested districts are frequently made.

LIFE HISTORY.

Observations on the life history and habits of this species have been reported by Townsend (1893), by Hunter and Hooker (1907), and by Hooker (1908).

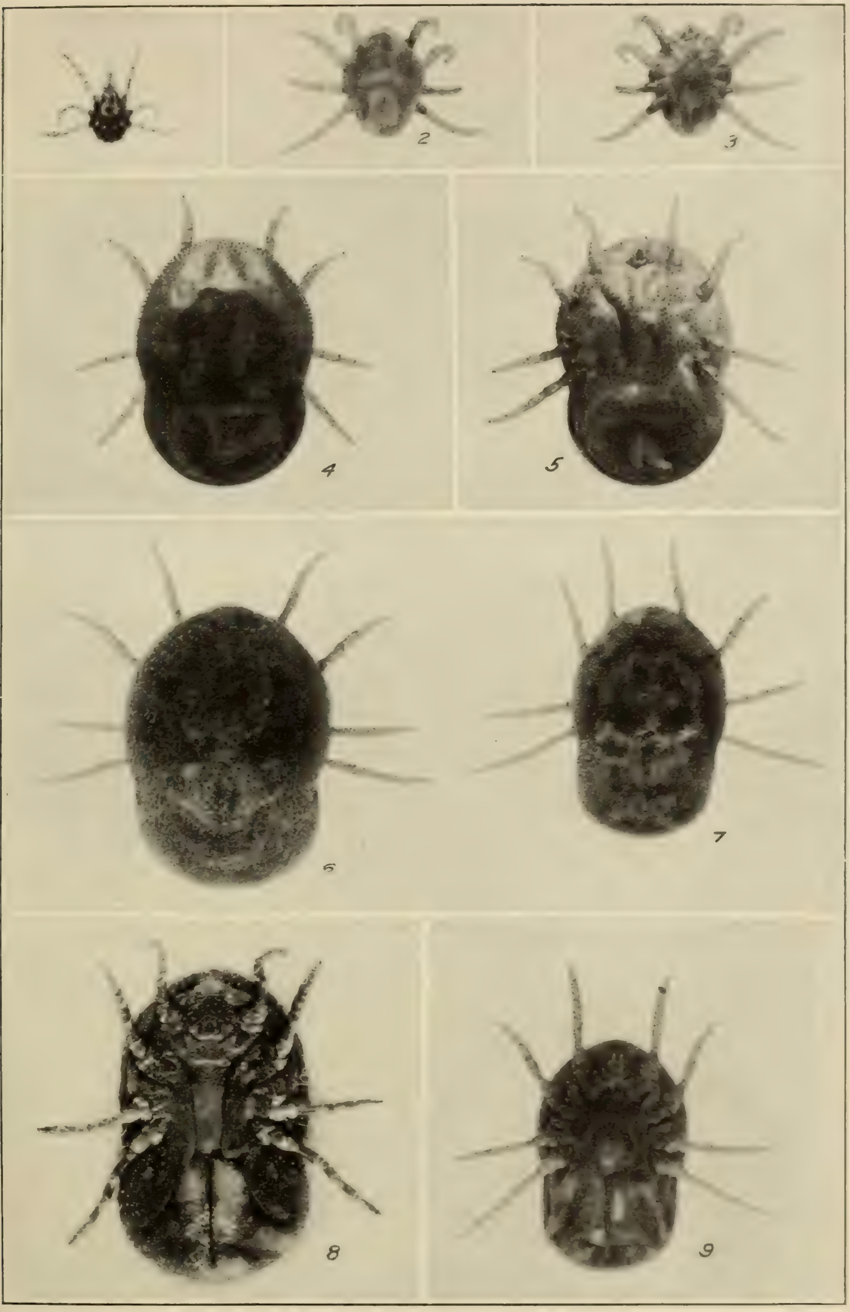
The egg.—With this species oviposition does not commence until mating has taken place. Large numbers of females have been isolated as nymphs in pill boxes and kept under observation for long periods after molting but in no case were eggs deposited in the absence of males. Where females after molting were at once placed in pill boxes with males, oviposition commenced in a comparatively short time. Of 13 females thus isolated, 3 commenced oviposition on the eighth day after molting; all had commenced on or before the twelfth day, with one exception, in which case eggs were first laid on the fifteenth day. The largest number of eggs deposited by any one of these 13 ticks was 1,546, the minimum number was 358, and the average 814. The eggs last deposited by any of the 13 ticks were laid 191 days after the ticks molted.

Oviposition in this species is remarkable on account of its intermittent nature. One tick ceased deposition for a period of 83 days, then deposited a considerable number of eggs. This phenomenon is evidently not dependent upon climatic conditions.

The minimum incubation period observed in the laboratory was 10 days; 412° F. of effective temperature appear to be required for embryonic development.

TABLE XI.—*Incubation period and larval longevity of Ornithodoros megnini.*

Eggs deposited.	Hatching began.	Minimum incubation period.	All larvæ dead.	Temperature during incubation.			
				Maximum.	Minimum.	Average daily mean.	Total effective.
1908.	1908.	*Days.*		*°F.*	*°F.*	*°F.*	*°F.*
Mar. 15	Apr. 4	21		88.0	46.0	68.03	526.17
27	Apr. 16	21		85.0	49.0	68.72	540.00
May 12	May 26	15		87.0	65.0	76.07	496.00
13	do	14		87.0	65.0	76.07	463.00
15	May 27	13		87.0	67.0	76.98	441.75
17	May 28	12		87.0	68.0	77.33	412.00
26	June 6	12	Before July 9	88.5	70.0	80.04	444.50
29	June 8	11	do	90.0	70.0	81.30	421.25
June 4	June 15	12	July 10	91.5	69.0	80.19	446.25
8	June 20	13	Before July 9	91.5	69.0	80.29	484.75
18	June 29	12	July 11	90.0	73.0	81.63	461.50
29	July 10	12	July 27	93.0	70.5	81.00	456.00
July 26	Aug. 4	10		95.0	78.0	85.75	427.50
31	Aug. 9	10		99.0	73.0	86.25	432.50



THE SPINOSE EAR TICK, ORNITHODOROS MEGNINI.

Fig. 1.—Unengorged larva. Fig. 2.—Slightly engorged nymph, dorsal view. Fig. 3.—Slightly engorged nymph, ventral view. Fig. 4.—Engorged nymph, dorsal view. Fig. 5.—Engorged nymph, ventral view. Fig. 6.—Engorged female, dorsal view. Fig. 7.—Male, dorsal view. Fig. 8.—Female from which all eggs have been deposited, ventral view. Fig. 9.—Male, ventral view. (Original.)

The larva (Tables XI, XII, XIII).—The seed ticks of this species soon succumb if exposed to moisture such as is required by the ixodid ticks when kept in tubes on sand. When kept in dry pill boxes after hatching some have died in a few days while others have lived nearly a month. On April 22, 1910, about 2,000 eggs deposited between April 8 and April 22 were placed in a tube out of doors. On May 19 most of the eggs had hatched. On July 27 only 5 or 6 larvæ remained alive, and the last tick died August 3. Thus it appears that a period of 103 days may elapse from the deposition of the eggs to the death of the last larva. The larvæ usually remain in a dense bunch when not disturbed, but if aroused they become very active. Upon gaining access to the ear they attach to the sides of the concha.

As is shown in Table XII larvæ may molt as soon as the seventh day. In the five infestations recorded all had molted by the twelfth day after application to the ear. The appearance of the engorged larva has led several authors to speak of it as a pupa-like stage. It is not a resting stage, as the engorged larvæ move about when detached from the host. However, there may be a brief period of quiescence immediately prior to molting as occurs in the case of most ticks.

The nymph (Tables XII, XIII).—The nymphs engorge very slowly and require a comparatively long time for development. In feeding they usually produce scabs, which peal off in layers beneath and about the tick, thus requiring occasional reattachment. There appears to be a great variation in the period that the nymphs remain upon the host. In our observations the first nymph to leave was found in the bag attached to the ear on the thirty-first day after attachment as a seed tick or about three weeks after the larval molt. Others have remained attached to the host for nearly 7 months (209 days) and would undoubtedly have remained longer had it not been that the host was unwittingly sprayed with naphtholeum by an assistant. Our observations indicate that nymphs when well engorged may at times be dislodged by violent exercise on the part of the host.

In order to determine whether the cotton bags tied to the ears influenced the ticks in leaving the host, the bags were removed at intervals, when the exact number of ticks attached in the ears could be determined. Apparently they were not thus influenced in any way. It seems quite probable that normally the nymphs leave the host at night while the latter is at a resting place, in the corral or stable. The fact that they crawl up several feet from the ground and secrete themselves in cracks and crevices of the boards and timbers near the mangers, in the bark of trees, etc., was first observed by Mitchell, as reported by Hunter and Hooker (1907). Hooker has noticed this same habit in observations made at an infested dairy in the vicinity of Corpus Christi, Tex. The cracks and crevices in front of the mangers were examined and numerous adults (both alive and dead), eggs, and larvæ were found. The greatest number were secreted several feet above the mangers. By crawling up in this way they find the dry quarters that appear to be required for development. Such a habit is of advantage to the larvæ in finding their way to the ears of the host, as cattle using infested stalls or rubbing against infested trees and fences undoubtedly pick up large numbers.

Our records show that nymphs may molt as soon as the sixth day after dropping. The spines characteristic of the nymphal stage are shed with the molted skin and are not found upon adults.

The adult (Tables XII, XIII).—In the adult stage this tick never engorges blood, a habit, so far as known, unlike that of any other species of tick. During the long periods of feeding as a nymph, development appears to take place sufficiently so that oviposition commences directly following fertilization, which may be as soon as 8 days after molting, or possibly sooner. The females may live for long periods if they do not find mates; thus a female collected July 22, 1905, and kept isolated in a small pill box (molting 6 days later) lived until January 22, 1907, a period of approximately 18 months. During this period no eggs were deposited. The longevity of 13 females varied from 66 to 260 days with an average longevity of 138.5 days. Males were placed with these as soon as the females became adult (molted). The longevity of these males varied from 77 to 166 days with an average of 100 days. These males and females were the largest individuals selected from a considerable number of collected nymphs. The greatest adult longevity observed in our investigation exceeded 638 days.

As in other argasid ticks, the sexes may be readily distinguished by the shape of the genital opening; in the female it appears as a transverse slit, while in the male it takes the form of a crescent.

Mating.—The species has frequently been observed in copulation in pill boxes. We have never observed the proboscis of the male inserted in the vulva as occurs in *Argas miniatus*, although this probably occurs. Christophers, who has studied ticks in India, states (1906, p. 9) that with *Ornithodoros savignyi* when placed in glass or porcelain vessels, a rapid tapping sound is sometimes heard which appears to be due to a vibration of the hinder portion of the body. We have frequently heard a tattoo-like sound made by adults of *O. megnini* kept in pill boxes and have considered it a sexual call. Upon removing the cover from the boxes the sounds have stopped and we have never observed a tick during the process. It appears that this habit is characteristic of the genus.

TABLE XII.—*The parasitic period of development of Ornithodoros megnini on a bovine.*

INFESTATION No. 1.

1907. Aug. 31, 2 p. m. Larvæ placed in ears.

1907. Sept. 8, 9 a. m. (8th day). Several molted.

1907. Sept. 9, 9 a. m. (9th day). All molted.

1907. Oct. 4 (34th day). One nymph dropped, molted to a male 11 days later (Oct. 15).

1907. Oct. 15 (45th day). One nymph dropped, molted to a male 13 days later (Oct. 28).

1907. Nov. 5 (65th day). One nymph dropped.

1907. Nov. 8 (68th day). One nymph dropped (8 by 5 by 3 mm.), molted to a male 31 days later (Dec. 9).

1907. Nov. 18 (78th day). One nymph dropped (7 by 4 by 2.5 mm.), molted to a male 13 days later (Dec. 1).

1908. Mar. 13 (195th day). One nymph dropped.

1908. Mar. 27 (209th day). The remaining nymphs (3) dropped. These were probably affected by spraying of the host Mar. 26.

INFESTATION No. 2.

1907. Oct. 13, 11 a. m. Larvæ placed in ear.

1907. Oct. 21, 9 a. m. (8th day). One molted.

1907. Oct. 23 (10th day). All but two or three molted.

1907. Oct. 25 (12th day). All molted.

1907. Nov. 4 (22d day). One nymph was removed, molted (Nov. 28) 24 days later.

1907. Dec. 3 (51st day). One nymph dropped.

1907. Dec. 4 (52d day). Two nymphs dropped.

1907. Dec. 5 (53d day). Two nymphs dropped.

1907. Dec. 23 (70th day). One nymph dropped.

1907. Dec. 24 (71st day). One nymph dropped.

1908. Jan. 14 (93d day). The last nymph dropped (dead).

INFESTATION No. 3.

1908. Apr. 7, 9 a. m. Larvæ placed in ear.

1908. Apr. 14, 4 p. m. (7th day). Two molted.

1908. Apr. 15 (8th day). All molted.

1908. Apr. 24. Three removed.

1908. May 8 (31st day). One nymph dropped (7 by 4 by 2 mm.).

1908. May 13 (36th day). One nymph dropped (7.5 by 5 by 3 mm.).

1908. May 17 (40th day). One nymph dropped (7 by 4.5 by 3 mm.).

1908. June 17 (71st day). Four nymphs dropped.

1908. June 22–29 (76th–83d day). Two nymphs dropped.

1908. Aug. 7 (121st day). Two nymphs dropped (7 by 4.5 by 2.5 mm; 8 by 5 by 3 mm.).

1908. Aug. 11 (124th day). One nymph removed (7 by 4.5 by 2.5 mm.).

1908. Sept. 8 (154th day). One nymph dropped (7 by 4.5 by 3 mm.).

1908. Sept. 24 (170th day). One nymph dropped.

1908. Oct. 2 (178th day). One nymph dropped during process of spraying host.

INFESTATION No. 4.

1908. July 2. Larvæ placed in ear.

1908. July 12 (10th day). Several molted.

1908. July 14 (12th day). All molted.

1908. Aug. 26 (24th day). Cotton-seed oil poured into ear, but none dropped.

1908. Aug. 31 (29th day). One dead (in bag), 5 attached.

1908. Sept. 10 (39th day). Chloronaphtholeum (1 to 75) poured into ear but none dropped

1908. Sept. 24 (53d day). One nymph dropped.

1908. Oct. 10 (67th day). One nymph dropped.

1908. Oct. 12 (69th day). Three nymphs still present.

INFESTATION No. 5.

1909. June 10. Larvæ placed in ears.

1909. July 18 (8th day). Two molted.

1909. July 19 (9th day). Two molted.

1909. Aug. 6 (57th day). First nymph dropped.

1909. Oct. 1 (113th day). Last two nymphs dropped.

TABLE XIII.—*Summary of parasitic periods of Ornithodoros megnini.*

Infestation.	Larvæ.						Nymphs.				Total parasitic period.
	Attached.	First molted.		Last molted.		Parasitic period.	First dropped.		Last dropped.		
		Date.	Period following attachment.	Date.	Period following attachment.		Date.	Period following attachment.	Date.	Period following molting.	
	1907.	1907.	*Days.*	1907.	*Days.*	*Days.*	1907.	*Days.*	1908.	*Days.*	*Days.*
1	Aug. 31	Sept. 8	8	Sept. 9	9	8–9	Oct. 4	34	Mar. 27	201	209
2	Oct. 13	Oct. 21	8	Oct. 25	12	8–12	Dec. 3	51	Jan. 14	85	93
	1908.	1908.		1908.			1908.				
3	Apr. 7	Apr. 14	7	Apr. 15	8	7–8	May 8	31	Oct. 2	171	178
4	July 2	July 12	10	July 14	12	10–12	Sept. 24	53	Oct. 12[1]	59	69
	1909.	1909.		1909.			1909.		1909.		
5	June 10	July 18	8	July 19	9	8–9	Aug. 6	57	Oct. 1	105	113

[1] 3 attached.

LIFE CYCLE.

The larvæ may live under favorable conditions for 80 days. Upon gaining access to the ear they attach on the inside in the fold of the concha and even in the meatus, engorge, and molt in from 7 to 12 days. The nymphs engorge more slowly and digest blood as they develop. They may leave the host as soon as 31 days after molting or may remain for 201 days and probably longer. Upon leaving the host they usually crawl up several feet from the ground and secrete themselves in dry cracks and crevices. Here they molt, are fertilized, and deposit eggs. The incubation period in summer has been as short as 10 days. An effective temperature of at least 412° F. appears to be required for embryonic development. Unlike other ticks, this species never engorges blood in the adult stage.

The larvæ and more especially the nymphs are to be found on the host at all seasons of the year, although their seasonal abundance varies somewhat with local climatic conditions.

ECONOMIC IMPORTANCE.

This tick is undoubtedly of much more importance economically than is generally supposed. It is the source of great irritation to the host as evidenced by frequent and repeated shaking of the head. Townsend (1893) states that horses when badly infested have been known to roll as well. It is particularly injurious to calves which, unless treated and the ticks removed from their ears, frequently die as a result of the irritation. In some cases they run about shaking and rubbing the ears until exhausted. The milk yield of dairy cattle is undoubtedly lessened and in beef cattle the gain in weight correspondingly affected. On the range in the worst infested districts the loss of many head of cattle is chargeable to this tick. The deaths occur mainly during the winter and early spring, particularly when feed is short and the cattle are poor. The ranchmen state that a heavily infested animal can often be told by the rough appearance of the hair.

There are numerous instances of this tick infesting the ears of man. Simpson (1901) reports a case in which two nymphs were taken, one from each ear of a gentleman in England who had camped in Arizona two months previous. The minute larvæ readily gain access to the external meatus of the human ear, where they develop to nymphs before causing much irritation. Intense pain may be caused by its presence, but usually there are no serious consequences.

NATURAL CONTROL.

We have observed that occasionally nymphs, which enter the meatus, are killed by being coated by the wax secreted in the ears of cattle. No natural enemies have been observed. Considerable moisture appears to be injurious to the nymphs and adults.

ARTIFICIAL CONTROL.

Dairy cattle and calves in infested districts should be frequently examined, the ticks removed, and some mild oil introduced into the ear. Townsend (1893), reporting upon this tick as observed in New Mexico, states that "a mixture of 20 parts of sweet oil to one of laudanum is sometimes poured into the ear as a remedy, but is of doubtful efficiency." Train oil, sometimes called British oil, he says, is highly recommended and he believes that it, as well as fish oil, will prove effective, but warns against the use of kerosene oil, which in the pure state has been known to cause temporary deafness. Townsend states that Dr. W. B. Lyon, of Las Cruces, N. Mex., recommended a little chloroform or carbolic acid in sweet oil or the dusting of calomel into the ears of affected horses.

In order to determine the value of cottonseed oil as a remedy, on August 26, 1908, some of it was poured into the ear of a bullock upon nymphs which had developed from larvæ applied on June 2. The results were negative. On September 10 chloronaphtholeum (1 to 75) was poured into the ears of the same animal without causing any of the ticks to drop.

DEVELOPMENT OF THE IXODIDÆ.

The second of the two families, the Ixodidæ or typical ticks, is represented in this country by 8 genera, including 36 described species and 3 varieties.

As based upon their molting habits, the ixodids may be divided into three groups: (1) The one-host ticks, or those that pass both molts upon the host; (2) the two-host ticks, or those which pass the first molt on the host but drop for the second, and (3) the three-host ticks, or those which drop for both molts.

The life cycles of 15 species and 2 varieties, representing the genera Margaropus, Rhipicephalus, Dermacentor, Hæmaphysalis, Ixodes, and Amblyomma, have been followed and are here considered. All molt twice and all but three drop from the host for both molts. *Dermacentor nitens*, *Margaropus annulatus*, and *M. annulatus australis* pass both upon the host. One other species, *Dermacentor albipictus*, has also been found by us to pass both molts upon the host. Molting closely follows engorgement in species which do not leave the host, while with those which drop, a quiescent period of 6 days or more follows. Some species burrow into the soil to the depth of an inch or more to pass the quiescent period and are thus afforded protection and drying out is largely prevented.

As with the Argasidæ the oviposition, incubation, and molting periods vary with the temperature, while the periods of engorgement upon warm-blooded hosts are but slightly influenced. The female usually dies within a few days after oviposition is completed. The color of engorged ticks varies considerably, particularly in the immature stages; the color may be nearly white, pink, slate-gray, or black, dependent upon the comparative amounts of blood, lymph, and inflammatory exudate imbibed.

Table XIV shows the maximum and minimum periods of engorgement, molting, and preoviposition in the species studied by us. Owing to the fact that the figures for some of the species are based upon a small number of observations made at one time of the year, they are hardly comparable with others which are chosen from a larger number of records made under various temperature conditions.

TABLE XIV.—*Maximum and minimum periods of engorgement, molting, preoviposition, and incubation of the ixodid ticks treated herein.*

Species.	Larvæ.		Nymphs.		Females.		Incubation period of eggs.
	Engorgement period.	Molting period.	Engorgement period.	Molting period.	Engorgement period.	Preoviposition period.	
	Days.	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*
Amblyomma americanum	3–9	8–26	3–8	13–46	9–24	5–13	23–117
Amblyomma cajennense	3–27	10–73	3–13	12–105	7–12	9–20	37–154
Amblyomma dissimile	4–16	7–16	5–14	12–32	28	6	27–40
Amblyomma maculatum	3–7	7–121	5–11	17–71	14–18	3–9	21–10
Amblyomma tuberculatum	....	86–165	8–11	29–207	20–25	8–10	91–112
Dermacentor nitens	(1)	8–16	(1)	17–29	[2] 9–23	3–15	24–394
Dermacentor occidentalis	2–7	6–12	3–9	13–22	7–10	4–17	21–38
Dermacentor parumapertus marginatus	4–14	8–39	4–25	21–123	9–26	5–6	20–24
Dermacentor variabilis	4–7	7–11	4–8	6–25	8–16	5–14	24–43
Dermacentor venustus	2–8	6–19	3–9	11–170	8–17	5–17	16–36
Hæmaphysalis chordeilis	5–12	14–92	5–8	26–186	19	....	....
Hæmaphysalis leporis-palustris	4–10	18–134	4–8	13–124	17–35	3–15	22–40
Ixodes kingi	4–16	27–163	5–66	29–34	....	19–65	26–53
Ixodes scapularis	3–9	23–31	3–8	25–26	7+–30+	15–16	72
Margaropus annulatus	(1)	5–16	(1)	6–20	[2] 5–19	1–66	19–202
Margaropus annulatus australis	(1)	6–9	(1)	8–13	[2] 7–13	1–7	24–34
Rhipicephalus sanguineus	3–6	6–29	4–9	12–29	6–50	3–83	19–142

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[1] This species molts on the host; hence the engorgement and molting periods can not be definitely separated, and are combined in the molting column.

[2] These periods include the number of days from the molting of the first nymph to the dropping of the first engorged female, and from the molting of the last nymph to the dropping of the last female.

LONGEVITY.

The period of life of the free ticks while awaiting a host is of particular importance economically. In general the larvæ of the species which pass their molts upon the host appear to be shorter lived than those of other ixodid ticks. *Dermacentor albipictus*, which molts upon the host, is an exception, however, as the larvæ of this species exhibit great longevity. Moisture is one of the most important factors in determining the longevity of ticks. After larvæ become weakened by fasting, a damp period has been observed to furnish conditions favorable to the development of various fungi upon them and to result in the destruction of large numbers. However, a certain amount of moisture is essential. The absence of moisture, especially during hot weather, is even more destructive than an excessive amount. The free nymphs are usually longer lived than the larvæ; in a number of species they have been found to live as long as the adults. According to Dixon (1910, p. 26) Lounsbury has found adults of *Rhipicephalus evertsi* to be alive, when kept in bottles, after a period of 18 months. Table XV summarizes our data on the longevity of the species observed. These records can not be considered as falling exactly into either of the two seasonal divisions used, as some were made during the spring and fall and others include part of summer and part of winter.

TABLE XV.—*Maximum longevity recorded for species of Ixodidæ.*

Species.	Larva.		Nymph.		Adult.	
	Summer.	Winter.	Summer.	Winter.	Summer.	Winter.
	Days.	*Days.*	*Days.*	*Days.*	*Days.*	*Days.*
Amblyomma americanum	[1] 150	[2] 297	476	476	393–430	393–430
Amblyomma cajennense	[2] 386	[2] 386	408	408	466	466
Amblyomma dissimile	[1] 95	....	130	....	129	103
Amblyomma maculatum	[2] 107	[2] 179	....	....	388–411	388–411
Amblyomma tuberculatum	....	[1] 95–110	81+	....	90	....
Dermacentor nitens	[1] 89–117	....	....	....	....	....
Dermacentor occidentalis	[2] 105–124	[2] 81	69	76–108	243+	243+
Dermacentor parumapertus marginatus	[1] 227	[1] 227	....	175	115–158	....
Dermacentor variabilis	[2] 335	[2] 335	200–216	200–216	202	233
Dermacentor venustus	[2] 92	....	185	252–271	413+	413+
Hæmaphysalis chordeilis	[2] 39+	....	....	74+	305	305
Hæmaphysalis leporis-palustris	[2] 258	[2] 217	342	342	588	588
Ixodes kingi	[2] 209	[2] 215+	....	68–171	104	....
Ixodes scapularis	....	75+	60+	....	....	....
Margaropus annulatus	[2] 125	[2] 279	....	....	....	....
Margaropus annulatus australis	[2] 82	....	....	....	....	....
Rhipicephalus sanguineus	[2] 80	[2] 131–138	75	183	158	214

[1] Record based upon larvæ hatched from eggs deposited on 1 or 2 days. Longevity computed from beginning of hatching to death of last larva.

[2] Record based upon larvæ hatched from all eggs deposited by a female. Longevity computed from beginning of hatching to death of last larva.

PARASITIC PERIOD.

There are a number of factors that influence, more or less, the parasitic periods of the ixodid ticks. Among these are the point of attachment to the host, fertilization, inability to detach, body temperature of the host, and, especially on cold-blooded hosts, the atmospheric temperature. Engorgement may take place somewhat sooner when the tick is attached at a place where the epidermis is thin and the hypostome reaches an abundant supply of capillaries than where the epidermis is thicker and a poorer blood supply is found. Usually ticks attach in favorable locations on the host's body. However, we have found *Amblyomma tuberculatum* to attach to the edge of the carapace of the tortoise where the blood supply is exceedingly poor and probably insufficient ever to produce engorgement. Few observations have been made on the variation in the time required for engorgement upon cold-blooded animals from that on warm-blooded hosts. The few records that we here present, however, are sufficient to show that much longer periods are required upon cold-blooded hosts even at summer temperatures. On such hosts the parasitic periods will undoubtedly be found to vary with the temperature to which they are exposed and, as the temperature falls, the difference between the parasitic period on warm-blooded and cold-blooded animals will probably be found to increase.

Upon warm-blooded hosts, fertilization appears to be an important factor influencing the engorgement of females. While they usually engorge quite rapidly after being fertilized, we have observed unfertilized females to dry up and die while awaiting a mate; others, apparently unfertilized, have been observed to engorge, though not to repletion, and usually much slower than fertile ones. However, in some cases at least, engorgement has been observed to proceed equally as rapidly in unfertilized as in fertilized ticks. Definite conclusions can not be drawn in regard to this point until further observations are made. Some ticks do not engorge to repletion owing to the formation of scabs at the points of attachment, which are sloughed off along with the tick. Frequently, being unable to detach from the scab and unable to obtain blood, the tick dies attached to the host. We have frequently observed specimens which were very weak when applied to a host to die shortly after attachment. The species of ticks with short hypostomes often leave the host as soon as it is killed, but this is not the case with those having long hypostomes. Lounsbury (1899) has the following to say in regard to this habit:

> Ticks of various kinds have been credited by different people with leaving an animal the moment death takes place. My observation does not confirm this statement. Mr. Roberts shot a badly infested cow while I was at Cottesbrook, and I was particular to watch the behavior of the ticks. None but a few fully-engorged blues [*Margaropus decoloratus*] fell off at first. The pelt was removed and spread out on the grass. There were several dozen male tortoise shells [*Amblyomma hebræum*] and plenty of blues and reds [*Rhipicephalus evertsi*] and a few striped legs [*Hyalomma ægyptium*] present. Many of the males of all four kinds and a small proportion of the females detached themselves and wandered about the skin on the second and third days, but the majority of all kinds remained attached up to the fourth day, when because of the unbearable stench I discontinued my observations. Later it was observed that vast numbers of the ticks had dried out without disengaging themselves.

PREOVIPOSITION.

Following engorgement the female drops from the host, crawls to some protective covering, as into sand, cracks in the soil, beneath vegetation, litter, boards, or into cracks and crevices in buildings. In summer oviposition may commence as soon as the day following dropping, but usually the preoviposition period is of somewhat greater duration. In cold weather it may be delayed for as long as several months.

THE EGG.

The deposition of eggs continues in summer from one to two or more weeks, while during the colder months it may continue from one to several months. With the ixodid ticks oviposition occurs but once, during which time from one to many thousand eggs may be laid; with the completion of oviposition the female dies. The shortest incubation periods observed in the several species studied vary from 16 to 91 days. The longest incubation period recorded was 202 days. Temperature is the principal influencing factor, although humidity has some effect, particularly on the percentage of eggs hatching.

The manner of oviposition by Ixodes was first described correctly by Gené (1845), and later by Bertkau (1881). Curtice (1892, p. 242) first described the process in *Margaropus annulatus*, Lewis (1892) in *Amblyomma coronatum*, and Wheler (1906) in *Ixodes ricinus*. A detailed account of the process in *M. annulatus* has been given by Cushman as reported by Hunter and Hooker (1907, p. 16). Lewis's report of observations and that of Wheler are accompanied by illustrations and Cushman has made a drawing which we here present (see p. 127, fig. 9) of the organ protruded by *Amblyomma tuberculatum*. During oviposition the capitulum is retracted and a viscid vesicle to which Gené gave the name *vesica biloba* is protruded from between the capitulum and the scutum, from the lateral extremities of which two elevations are thrown out to be lengthened by evagination into two horns, lobes, or papillæ, as they have been described, which receive the eggs from the protruded oviduct. The glands of this vesicle secrete a viscid substance with which the lobes coat the eggs, thus causing them to adhere in a mass, and furnishing protection from drying. Gené found that eggs laid after destroying this sac, thus preventing the eggs from being covered, dried up and would not hatch, while others, newly laid by the same female and coated, hatched. Our observations appear to confirm those of Gené. In the case of the specimen of *A. tuberculatum* here figured, this sac was accidentally injured, resulting in the deposition of eggs which soon became dark and shrunken.

THE LARVA.

Upon hatching, the larvæ of many species remain clustered together for several days near the eggshells. Finally they crawl upon nearby herbage, such as grass, weeds, and even small trees, posts, or buildings, and there await the passing of a host. Some ticks, such as the species commonly found on dogs and rabbits, drop near the kennels or sleeping places of the hosts, and when the larvæ are ready to attach they may crawl about in search of the host.

Having once found a host the larvæ cling with great tenacity, crawling about over the body until a suitable place for attachment is found. The position of attachment upon the host varies with the species. Attachment may take place at once, or the tick may wander about for several days before attaching. This delay in attachment, the quantity and quality of the ingesta obtained by different specimens, and individual vitality account, in part at least, for the variation of from 2 to 14 days in the period between the application to hosts and the dropping of engorged larvæ from warm-blooded hosts and of from 10 to 18 days in the case of cold-blooded animals. After dropping, engorged larvæ usually remain active for only a few days before becoming quiescent, during which time they crawl to some protective covering. In some species, however, a considerable period is passed before the engorged larvæ become quiescent. From 10 days to several weeks may be required for the metamorphosis of the larva. This quiescent period varies primarily with the species, the temperature, and the humidity, the first two being the more important.

THE NYMPH.

In general the longevity of the nymphs is somewhat greater than that of the larvæ. In awaiting the hosts, their habits are very similar to those of the larvæ. In those species which molt upon the host, the adults crawl from the nymphal exuvia and reattach nearby. The periods of engorgement are quite similar to those of the larvæ, but the quiescent periods are somewhat longer.

There is considerable variation in the size of the engorged nymphs. The smaller ones usually become males and the larger become females. In the species with color markings on the scutum, as in the species of Amblyomma, the markings can be seen through the skin that is about to be shed. The sex can thus be determined from one to several days before the molt takes place. Following engorgement, if passed upon the host, molting takes place after a very short quiescent period. With the species which drop for the nymphal molt, from 1 day to as much as 6 months of activity are passed prior to the quiescent period. During this period of activity the nymphs attempt to find some protected place in which to transform. Partially engorged nymphs usually have a much longer period of activity than fully engorged individuals. Low temperatures also lengthen this period. From 3 days to many months, varying somewhat with individuals, but particularly with the temperature, pass after the engorged nymphs drop before they transform to adults.

THE ADULT.

Upon molting, the adults may crawl upon herbage or other nearby objects and await a passing host. Some species, which commonly drop in places frequented by their hosts, may crawl about in search of them, as is the case with *Rhipicephalus sanguineus*. The longevity periods are usually somewhat greater than those of the nymphs. In the case of those species which molt on the host, the female, after issuing from the exuvium, reattaches nearby, while the male detaches and goes in search of a mate. Copulation usually takes place upon the host, but with several species of Ixodes it occurs off the host as well. There are also several records of species of other genera where copulation occurred when the ticks were not on a host, but we are inclined to the opinion that, aside from ticks of the genus Ixodes, mating very rarely occurs off the host. The periods required by adults for engorgement are usually longer than those of the immature stages, as fertilization must, as a rule, first take place. We have found this period to vary considerably even in the same species. Fertilization appears to be one of the principal factors involved; the quantity and quality of the ingesta and the vitality of the individuals are also important factors. The rate of engorgement is greatly increased after the female has become about one-half engorged. Occasionally fully engorged females are unable to detach and remain attached for several days after becoming fully engorged. Our records show that females have engorged and dropped as soon as 5 days after attachment, while others have remained upon the host as long as 50 days.

It has been found that females in the course of oviposition may first produce fertile eggs and later eggs which are dark, shrunken, and apparently infertile. Specimens of many of the species when not over one-third engorged may be detached and if uninjured will reattach. There is a great difference in the number of eggs deposited by the various species, varying with the size of the tick and also with the size of the eggs. This variation in the maximum number of eggs deposited ranges from 2,240 per tick in *Hæmaphysalis leporis-palustris* to as many as 11,265 by our native species, *Amblyomma maculatum*, and 20,000 by 2 African species (*A. hebræum* and *A. variegatum*). The males often remain upon the hosts for long periods after the females have dropped; thus the females usually do not have to wait long for a mate after finding a host. The habit of the male of remaining upon the host for a considerable time accounts for the fact that the males of the larger species, such as *A. maculatum* and *A. tuberculatum*, are more commonly collected than the females. It has been noted that with the species in which the male is small and inconspicuous the females have been more frequently collected.

Genus IXODES Latreille.

The genus Ixodes is represented by more species in the United States than any other genus. On account of this fact, the general distribution of the members of the group throughout the country, and the occurrence of the species on a large number of small mammals, no doubt a considerable number of undescribed forms will be found in the future.

The black-legged tick (*Ixodes scapularis*) and the California Ixodes (*Ixodes californicus*) are the species of most importance in this country. These species are both closely related to the European castor-bean tick (*Ixodes ricinus*), and are thought by Bishopp to be only varieties of the European form. This view is also held by Nuttall and Warburton.

None of the members of this genus has been connected with disease transmission in this country, but in Germany *Ixodes ricinus* has been shown by Kossel and his associates (1903) to be capable of transmitting bovine piroplasmosis, and Stockman (1908) has shown it to play the same rôle in England.

Ixodes ricinus, on account of its general distribution and importance in Europe, has received the attention of a number of investigators. This species has been studied in England by Wheler (1899) and in Germany by Kossel and his coworkers (1903). *Ixodes pilosus* has been studied by Lounsbury (1900–1906) and by Mally (1904). The life histories of only two species of the genus, namely, *Ixodes scapularis* and *Ixodes kingi*, are presented here, although several other species are now being studied. All of the species observed drop from the host to pass both molts.

THE BLACK-LEGGED TICK.

Ixodes scapularis Say.

DESCRIPTIVE.[1]

Adult (Pl. V, figs. 2, 3, 5–8).—Males about 2.3 by 1.25 mm. Females, unengorged, from 2.5 by 1.25 mm. to 3 by 1.5 mm.; engorged, about 10 by 7 by 5.5 mm. The females are usually dark brown, and the males almost black; scutum and legs in both sexes black, or nearly so. Partially engorged females that are nearly white, and others that are of a dark red color, are frequently found upon the host.

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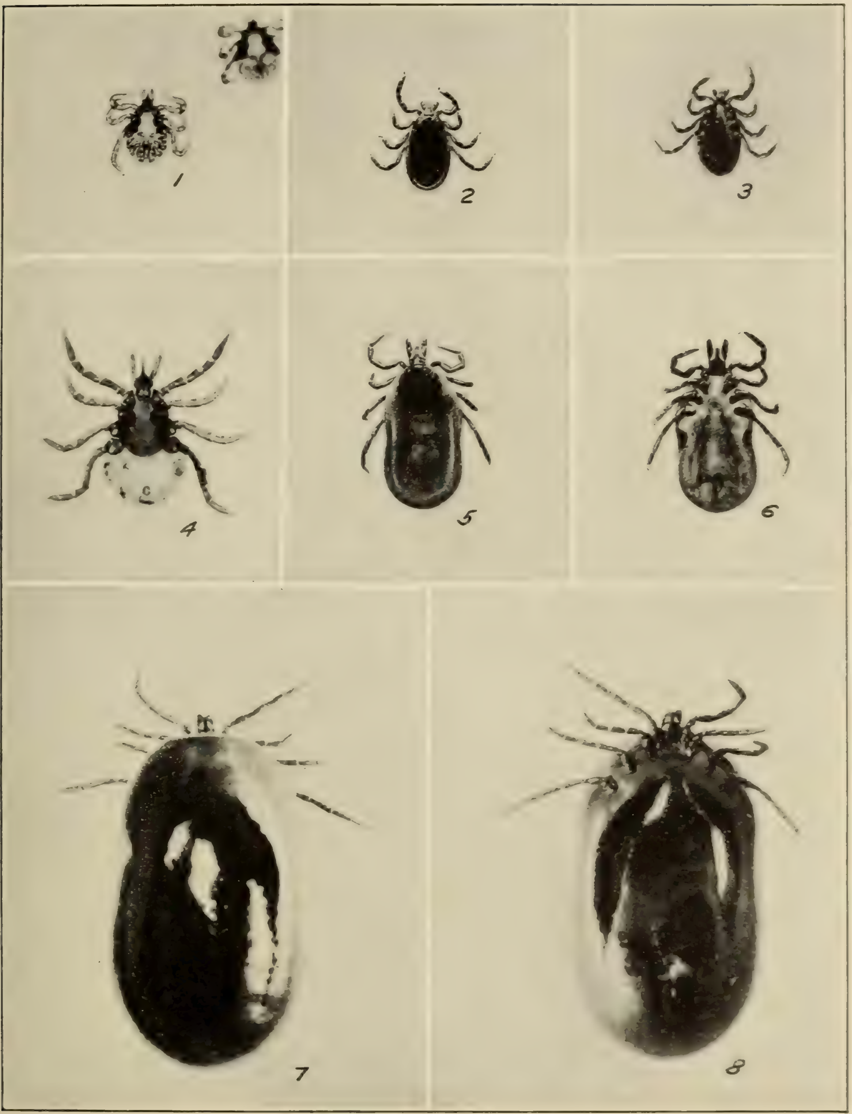
[1] The capitulum has been included in all the measurements of the length of this and other species recorded in this bulletin.



THE BLACK-LEGGED TICK, IXODES SCAPULARIS.

Fig. 1.—Unengorged larva. Fig. 2.—Male, dorsal view. Fig. 3.—Male, ventral view. Fig. 4.—Unengorged nymph. Fig. 5.—Partly engorged female, dorsal view. Fig. 6.—Partly engorged female, ventral view. Fig. 7.—Fully engorged female, dorsal view. Fig. 8.—Fully engorged female, ventral view. (Original.)

Nymph (Pl. V, fig. 4).—Unengorged, 1.5 by 0.75 mm.; engorged, from 2.3 by 1.5 by 1.25 mm. to 2.7 by 1.5 by 1.25 mm. Color, unengorged, dark smoky brown, shield and capitulum nearly black, legs lighter; engorged, dark bluish gray. Capitulum 0.317 mm. long (from tip of palpi to postero-lateral angles of basis capituli); scutum 0.586 mm. long by 0.491 mm. wide.

Larva (Pl. V, fig. 1).—Unengorged, from 0.616 by 0.371 mm. to 0.746 by 0.474 mm.; engorged, 1.28 by 0.76 mm. to 1.4 by 0.9 mm. Color, unengorged, smoky brown; scutum, capitulum, and legs somewhat darker than body; engorged, slate-gray to black. Capitulum 0.222 mm. long (from tip of palpi to base of emargination of shield); scutum 0.297 mm. long by 0.304 mm. wide.

Egg.—Size, about 0.445 by 0.386 mm.; light brown, shining, smooth.

HOST RELATIONSHIP.

No type host was given by Say when he described this species. In certain sections of the South it occurs in considerable numbers on the dog and on cattle. The species has also been recorded from the deer, sheep, horse, and, in the immature stages, from birds, including the quail, blue jay, and thrush. One of the writers has found this tick to be common on the dog at Hawthorn, Fla. Mr. W. W. Yothers collected a number of adults on dogs at Orlando, Fla. Both sexes were collected from an opossum at Hawthorn, Fla., and at Tanglewood, Tex., Mr. C. T. Atkinson took a partially engorged female on that host.

GEOGRAPHICAL DISTRIBUTION.

(Fig. 3.)

No type locality was given for this species by Say, who described it. It appears to have been collected from Maryland south to Florida, and in the Central States from Indiana, Iowa, and Missouri, as well as in Louisiana and Texas. A male specimen recorded from Pennsylvania by Neumann may prove to be this species. Some 12 female specimens collected from *Felis pardalis* in Costa Rica and determined by Neumann as *Ixodes affinis* have been identified by Mr. Nathan Banks as *I. scapularis*. Mr. E. A. Schwarz took a male and female when he was beating hanging vines in heavy timber, a short distance west of Tampico, Mex.

LIFE HISTORY.

But little has previously been published on the biology of this species.

The egg.—Two engorged females which were collected at Hawthorn, Fla., on December 21, 1907, and sent to the laboratory, commenced depositing, one on January 5, the other on January 6; 15 and

16 days, respectively, after collection. The eggs deposited were not counted, but it was estimated that at least 3,000 had been deposited by one of the ticks. A well-engorged female collected on a cow at Dallas, Tex., November 24, 1908, began depositing on December 11, thus having a preoviposition period of 17 days.

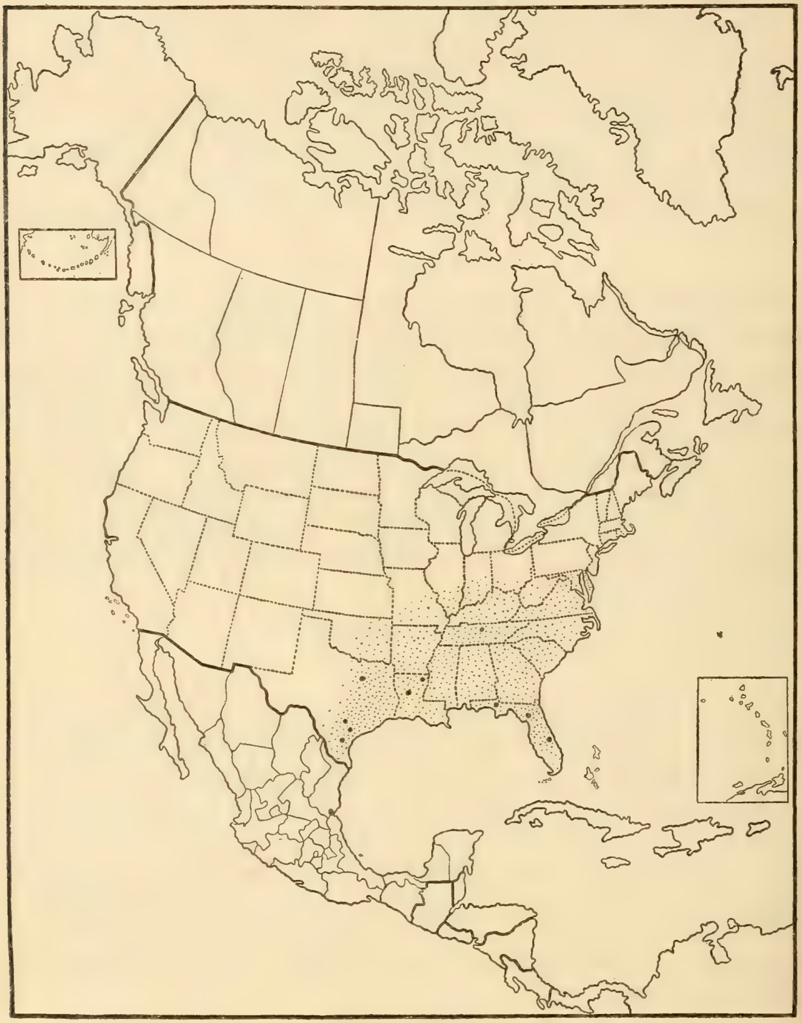


FIG. 3.—The black-legged tick, *Ixodes scapularis:* Distribution in the United States. The large dots show localities where the species has been collected in our investigation. The small dots indicate the probable range of the tick. (Original.)

In the laboratory at a mean temperature of 61° F., eggs deposited January 6 commenced hatching on March 17, an incubation period of 72 days. An accumulated effective temperature of 1,318° F. was required for their incubation.

The larva (Tables XVI, XVII).—Larvæ which hatched in March have lived for 2½ months in the laboratory and then attached to a bovine and engorged. Their longevity is undoubtedly considerably longer than this period.

Larvæ were found to engorge and leave the host as soon as 3 days after application, the longest period required being 9 days.

TABLE XVI.—*Engorgement of larvæ of Ixodes scapularis.*

Date larvæ applied.	Host.	Larvæ dropped engorged—days following application.									Total number dropped.
		1	2	3	4	5	6	7	8	9	
May 6, 1908	Bovine	0	0	18	12	5	0	0	0	0	35
May 23, 1908	...do...	0	0	0	1	0	7	22	3	1	34
May 6, 1909	...do...	0	0	2	1	0	0	0	0	0	3
May 11, 1909	...do...	0	0	1	0	0	0	0	0	0	1

In May at a mean temperature of 77.19° F. engorged larvæ have commenced to molt on the twenty-third day, the last to molt shedding its skin on the thirty-first day. Thus an accumulated effective temperature of 786° F. was required.

TABLE XVII.—*Molting of larvæ of Ixodes scapularis.*

Date engorged larvæ dropped.	Host.	Number.	Larvæ molted—days following dropping.									Total number molted.	Temperature from dropping to date first tick molted.		
			23	24	25	26	27	28	29	30	31		Maximum.	Minimum.	Average daily mean.
													°F.	°F.	°F.
May 9, 1908	Bovine	18	0	0	4	3	5	1	0	1	0	14	88.50	63.00	77.21
May 10, 1908	...do...	20+	2	3	5	1	1	0	8	0	0	20	87.50	65.00	77.19
May 11, 1908	...do...	5	0	3	2	0	0	0	0	0	0	5	88.50	65.00	77.62
May 29, 1908	...do...	4	0	1	0	Others dead.				0	0	1	91.50	69.00	80.72
May 30, 1908	...do...	3	2	0	0	0	0	0	0	0	1	3	91.50	69.00	80.86
May 31, 1908	...do...	3	0	0	0	0	0	0	0	0	1	1	91.50	69.00	80.90
May 14, 1909	...do...	2	1	0	0	0	0	0	0	0	0	1	97.00	47.00	86.64
Total		55										45			

The nymph (Tables XVIII, XIX).—A number of nymphs which molted in June lived 2 months in the laboratory and then attached to a host. Nymphs engorged and dropped as soon as the third day after application, the last to drop leaving the host on the eighth day.

TABLE XVIII.—*Engorgement of nymphs of Ixodes scapularis.*

Date nymphs applied.	Host.	Nymphs dropped engorged—days following application.								Total number dropped.
		1	2	3	4	5	6	7	8	
June 20, 1908	Bovine	0	0	1	0	3	1	4	2	11
July 10, 1908	...do...	0	0	0	0	1	1	0	0	2
July 11, 1908	...do...	0	0	0	0	2	0	0	0	2

A nymph molted in June in 25 days, when the mean temperature was 82° F. A total effective temperature of at least 955° F. was required. Thus an exceptionally high effective temperature appears to be required for the nymphal molt. There is also a considerable variation in the periods in which the nymphal molt takes place. The length of the molting period of nymphs which become males is practically the same as that for nymphs which transform to females.

TABLE XIX.—*Molting of nymphs of Ixodes scapularis.*

[♂=Male. ♀=Female.]

Date engorged nymphs dropped.	Host.	Number.	Nymphs molted—days following dropping.										Number molted.			Temperature from dropping to date first tick molted.		
			25	30	34	36	38	42	43	50	52	56	Male.	Female.	Total.	Maximum.	Minimum.	Average daily mean.
																°F.	°F.	°F.
June 23, 1908	Bovine..	1	...	...	...	1♀	...	...	...	...	...	...	0	1	1	95.0	70.5	82.74
June 25, 1908	...do.....	3	...	...	...	1♀	...	...	...	1♀	...	1♂	1	2	3	95.0	70.5	82.95
June 26, 1908	...do.....	1	1♀	...	...	...	...	...	...	...	...	...	0	1	1	94.0	70.5	82.20
June 27, 1908	...do.....	4	...	1♂	1♀	...	...	1♂	...	...	1♂	...	3	1	4	95.0	70.5	82.75
June 28, 1908	...do.....	2	...	...	...	...	1♀	...	...	...	...	...	0	1	1	95.0	70.5	83.45
July 15, 1908	...do.....	1	...	...	...	...	...	...	1♀	...	...	...	0	1	1	99.0	73.0	85.28
July 16, 1908	...do.....	2	...	...	...	1♂	...	...	1♀	...	...	...	1	1	2	99.0	73.0	85.76
Total...	....	14	...	...	...	...	...	...	...	...	...	...	5	8	13			

The adult.—The longevity of unfed males and females has not been determined owing to the limited supply of adults at hand. When removed from a host the adults do not live long unless kept quite moist; even the engorged females die unless they are kept under such conditions.

Males and females which would not attach when placed on a host September 1 attached readily when given an opportunity 4 days later. The following day they were found mated. On the morning of the second day the males had detached, but in the afternoon they were again paired. One male remained with a female for 4 days, while others changed to a second mate during this time. Our observations indicate that ordinarily mating is not continuous upon the host. It appears that mating may also take place off the host. We have observed an engorged, unattached female and an unattached male in coitu shortly after they were taken from the hair of a hunting dog. In the course of this act the mouthparts of the male are introduced into the genital pore of the female.

A partially engorged female, collected in Florida, engorged and dropped on the seventh day after attachment to a bovine at the laboratory. A female applied to a bovine September 1 attached 4 days later and remained attached until September 25, when it was rubbed off by the host. At that time it was about one-third engorged, measuring 4 by 2.2 by 1.4 mm. A second female attached at the same time was sloughed off on October 1, being but slightly engorged at that time. The reason these two females did not engorge more rapidly is not known. It was not due to a lack of fertilization, as mating took place while the ticks were on the host. A slightly engorged female that was applied to a bovine host on December 26, 1907, dropped 8 days later fully engorged, measuring 10 by 7 by 5.5 mm.

LIFE CYCLE.

Oviposition may commence in 15 days after dropping. Three thousand or more eggs are deposited by the engorged tick. In winter at a mean temperature of 61° F. incubation may take place in 72 days, a total effective temperature of 1,318° F. being required. Larvæ may engorge in 3 days and at a mean temperature of 77° F. commence to molt 23 days later, an accumulated effective temperature of 786° F. being required. Nymphs may engorge in 3 days after being applied to a host. In summer 25 or more days appear to be required for the nymphal molt. A total effective temperature of at least 1,017° F. appears necessary for this transformation. A slightly engorged female collected on a dog reattached and engorged upon a new host in 7 days.

ECONOMIC IMPORTANCE.

The black-legged tick is not known to be of any great economic importance. In Germany and England a closely related species, *Ixodes ricinus,* transmits bovine piroplasmosis and it is possible that this species may do so. While this tick has been found by Prof. H. A. Morgan to be rather numerous on cattle in northern Louisiana, it appears to be of minor importance as a cattle pest. In extensive collections made in Texas agents of this bureau have failed to find it in sufficient numbers to attract attention as a pest. In the vicinity of Hawthorn, Fla., however, it is the source of considerable annoyance to hunting dogs, and it has recently been found to be a pest of considerable importance to cattle and sheep in northern Tennessee.

NATURAL CONTROL.

Observations relating to natural enemies of this species are lacking.

ARTIFICIAL CONTROL.

Where hand picking is not sufficient to keep the species in control, mopping with one of the coal-tar products should be practiced.

THE ROTUND TICK.

Ixodes kingi Bishopp.

The common name of this species is applied on account of the globular form of the engorged female.

DESCRIPTIVE.

Adult (Pl. VI, figs. 4–9).—Males 2.85 by 1.51 mm. to 3.15 by 1.88 mm. Females, unengorged, 2.6 by 1.6 by 0.7 mm. to 2.7 by 1.7 by 0.7 mm.; engorged, 11.6 by 10.4 by 7 mm. to 13 by 12.8 by 8.5 mm.; unengorged males and females light yellowish brown; scutum somewhat darker; engorged females appear almost globular; shield and mouthparts inconspicuous; abdomen light blue-gray in color. The grooves on the dorsum and venter practically disappear on engorged specimens.

Nymph (Pl. VI, figs. 2, 3).—Unengorged, about 1.25 by 0.8 mm.; length of capitulum 0.37 mm. (from tip of palpi to base of emargination of scutum); scutum 0.66 mm. long by 0.68 mm. wide; body ovoid, yellowish brown, somewhat translucent; engorged, about 2.3 by 1.3 by 0.8 mm.; slate color, legs and shield light colored as before engorging.

Larva (Pl. VI, fig. 1).—Unengorged, 0.657 by 0.413 mm.; length of capitulum 0.19 mm. (from tip of palpi to base of emargination of scutum); scutum 0.277 mm. long by 0.335 mm. wide; body ovoid, very light yellow, translucent; engorged, 1.19 by 0.727 mm.; bluish gray in color.

Egg.—Ellipsoidal, light yellow, translucent. The maximum size of ten eggs was 0.541 by 0.420 mm.; the minimum size 0.528 by 0.392 mm. and the average size 0.534 by 0.401 mm.

HOST RELATIONSHIP.

The type host of this species is the badger. Our knowledge of the hosts of the immature stages of this tick is limited owing to the difficulty met with in rearing immature stages of Ixodes to adults, and to the fact that the specific identity of the larvæ and nymphs of Ixodes can not be reliably determined. Immature stages of what are very probably this species have been collected upon the following hosts: Badger, larvæ and nymphs; pocket gopher (*Thomomys clusius ocius*), larvæ; marmot (*Marmota flaviventer*), larvæ and nymphs; skunk, nymphs; dog, nymphs; pine squirrel (*Sciurus hudsonicus richardsoni*), larvæ and nymphs; pika (*Ochotona princeps*), larvæ and nymphs; chipmunk (Eutamias), larvæ and nymphs; ground squirrel (*Citellus columbianus*), larvæ and nymphs. Many of the above lots were collected by Mr. W. V. King in western Montana. The sexes were taken together on badger in three instances and on dog in two cases. Twenty lots have been collected in which females only were found. The hosts and number of lots on each is as follows: Dog, 8; pocket gopher, 2; prairie dog, 1; mink, 1; wolf, 1; spermophile, 1; marmot, 1; skunk, 1; kangaroo rat (*Perodipus richardsoni*), 1; unknown, 3. From the large number of ticks of both sexes found on the badger it would appear that that animal is one of the more important natural hosts of the species. We have been able to engorge the larvæ experimentally on the guinea pig, rabbit, and ox, and nymphs have been engorged on the guinea pig and ox.

GEOGRAPHICAL DISTRIBUTION.

(Fig. 4.)

The type locality of this species is Meeteetse, Wyo. The species appears to be widely distributed over the Western States from Texas to Montana. We have specimens which were collected in Texas, New Mexico, California, Utah, Wyoming, Idaho, and Montana. The tick appears to be most abundant in the northern part of its range. It is quite probable that this species occurs in Canada and possibly in Mexico, although no collections have been made in those regions.

LIFE HISTORY.

No studies have been made heretofore upon the biology of this tick.

The egg (Table XX).—Since specimens of this tick have not been engorged at the laboratory, only those sent in from various localities having been used in our studies, it is not possible to determine definitely the relation between the length of the preoviposition period and temperature.

During June and July, 1909, a preoviposition period of 19 days was recorded. This is the shortest preoviposition period which we have observed. The longest preoviposition period occurred during June, July, and August, 1909, and was 65 days. Four other specimens had preoviposition periods of 27, 28, 29, and 30 days, respectively. Deposition continued from 10 to 36 days. The shortness of the first period seemed to be due to the fact that the female was not fully engorged. The maximum number of eggs deposited by an individual was 4,706, and the average number 3,179. The females live but a short time after deposition is complete.

One female collected on June 23, 1909, began to deposit on the sixty-fifth day after collection. During the first 2 days of oviposition 454 eggs were deposited. On subsequent days deposition continued as follows: 104, 168, 169, 166, 107, 233, 59 (during 2 days), 43, 44, 9, a total of 1,556 eggs being deposited during 13 days. A female collected June 29, 1909, began to deposit on the twenty-sixth day after collection. On that date and subsequent days deposition proceeded as follows: 485, 226, 169, 231, 246, 156, 312 (during 2 days), 104, 105, 109, 103, 113, 234, 97, 100, 115, 84, 94, 66, 69, 48, 10, a total of 3,276 eggs being deposited during the period of 133 days. A third individual, for which the date of collection was not recorded, deposited as follows: From June 9 to 11, 72 eggs. On subsequent days, 319, 261, 372, 282, 306, 169, 181, 166, 130, 121, 105, 112, 148, 173, 142, 160, 152, 183, 102, 123, 121, 108, 118, 195, 80, 85, 115, 92, 13 (during 2 days), a total of 4,706 eggs being deposited during the period of 34 days. Many of the eggs deposited by the individual last

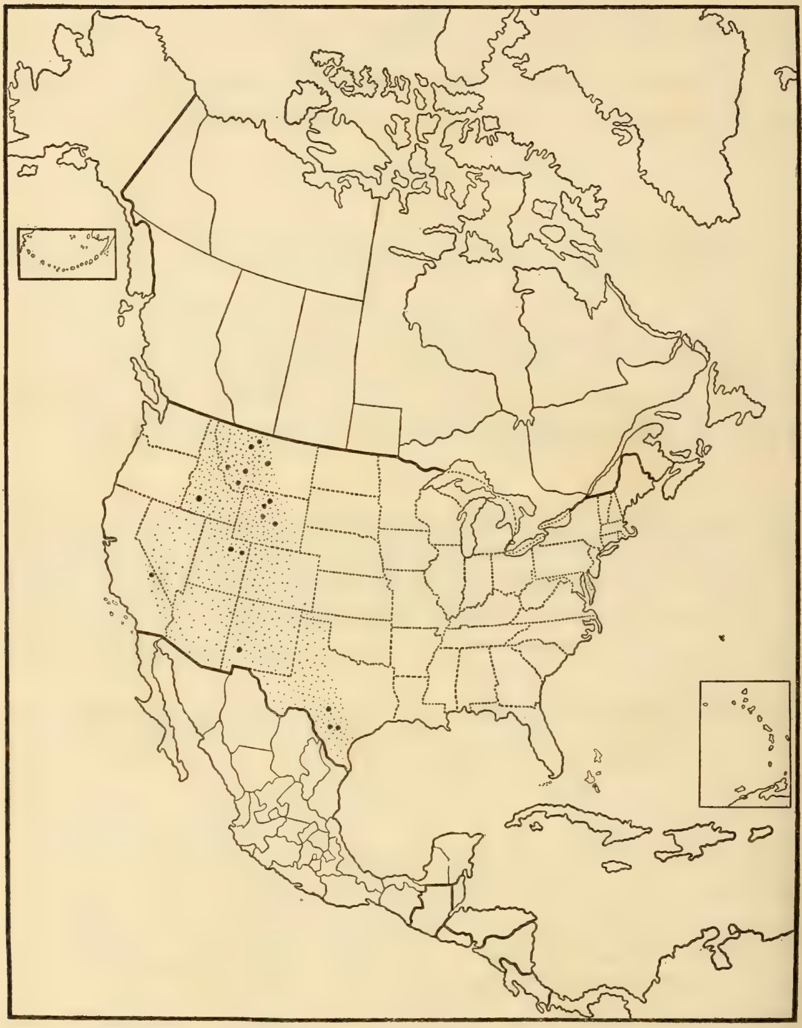
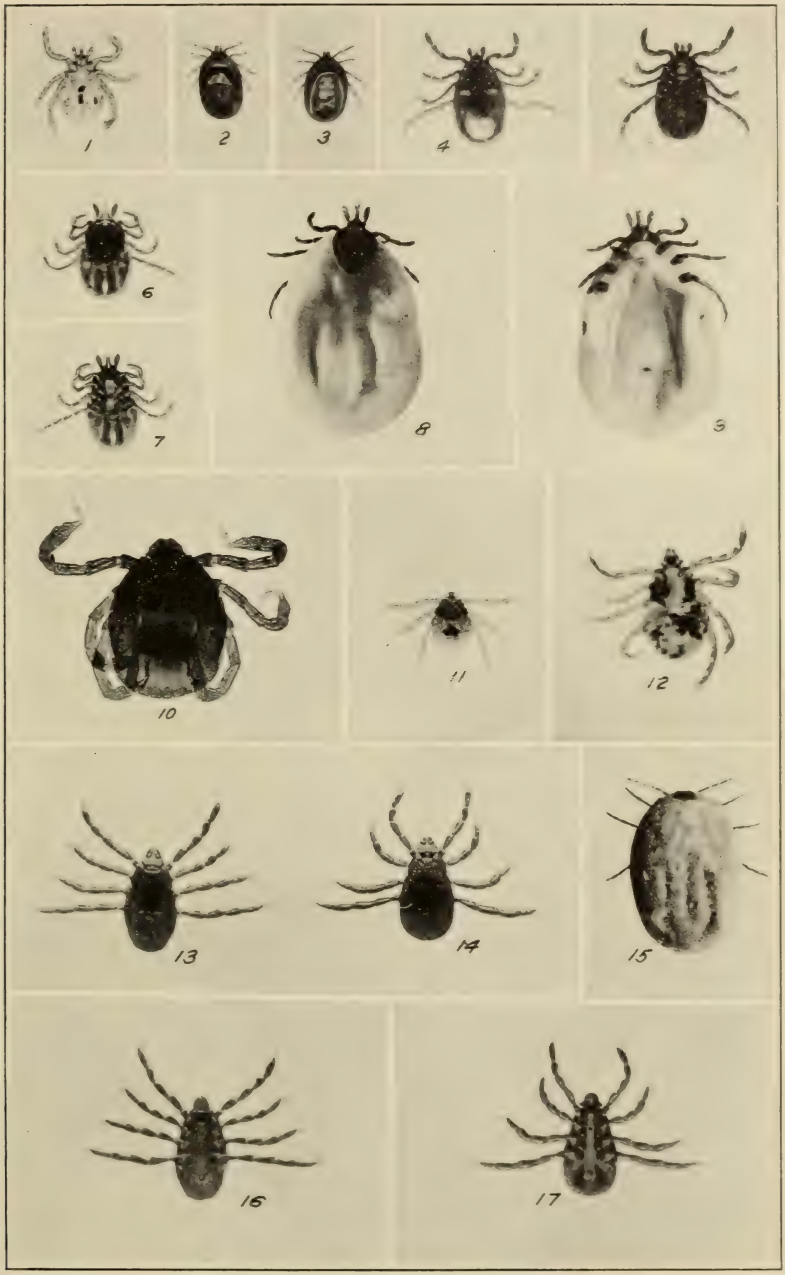


FIG. 4.—The rotund tick, *Ixodes kingi:* Distribution in the United States. The large dots show localities where the species has been collected in our investigation. The small dots show the probable distribution of the species. (Original.)



THE ROTUND TICK, IXODES KINGI, AND THE BROWN DOG TICK, RHIPICEPHALUS SANGUINEUS.

Ixodes kingi: Fig. 1.—Unengorged larva. Fig. 2.—Engorged nymph, dorsal view. Fig. 3.—Engorged nymph, ventral view. Fig. 4.—Male, dorsal view. Fig. 5.—Male, ventral view. Fig. 6.—Unengorged female, dorsal view. Fig. 7.—Unengorged female, ventral view. Fig. 8.—Partially engorged female, dorsal view. Fig. 9.—Partially engorged female, ventral view. *Rhipicephalus sanguineus:* Fig. 10.—Unengorged larva. Fig. 11.—Unengorged larva. Fig. 12.—Unengorged nymph. Fig. 13.—Unengorged female, dorsal view. Fig. 14.—Male, dorsal view. Fig. 15.—Partially "deposited-out" female, dorsal view. Fig. 16.—Unengorged female, ventral view. Fig. 17.—Male, ventral view. (Original.)

recorded were shriveled and brownish and failed to hatch. Another fully engorged female, collected on a dog, March 29, 1910, began depositing on April 28, and deposited 130 eggs during the next 5 days. A few days later this female began to turn dark and soon died. The eggs deposited failed to hatch, thus suggesting that the tick may not have been fertilized.

The minimum incubation period observed was 26 days. This record was made in the laboratory during September, 1909, when the mean temperature was 85.67° F. A maximum incubation period of 53 days occurred during August, September, and October with a mean daily temperature of 84.58° F. The total effective temperature required for embryonic development appears to be at least 1,109° F.

TABLE XX.—*Preoviposition, incubation, and larval longevity of Ixodes kingi.*

Engorged female collected.	Deposition began.	Hatching began.	Minimum incubation period.	All larvæ dead.	Larval longevity.	Temperature during incubation.			
						Max.	Min.	Average daily mean.	Total effective.
1909.	1909.	1909.	*Days.*		*Days.*	*°F.*	*°F.*	*°F.*	*°F.*
June 29	July 25	Sept. 1	39	Feb. 25–Mar. 30, 1910.	177–210	110	77	89.32	1,806.5
Do	July 29	do	35			110	77	89.25	1,618.8
Do	Aug. 13	Oct. 4	53	About May 1, 1910	About 178.	110	66	84.58	2,203.7
Do	Aug. 10	Sept. 28	50			110	56	84.74	2,387
Do	Aug. 15	Sept. 29	46			110	56	85.34	1,947.6
Do	Aug. 18	Sept. 24	38	Apr. 27–July 19, 1910	215–298	110	61	86.65	1,658.7
Do	Sept. 1	Sept. 26	26			101	61	85.67	1,109.4
1910.	1910.	1910.							
Mar. 29	Apr. 27	June 17	52	Before Sept. 25, 1910.	100	100	62.75	75.36	1,682.7
Apr. 7	May 16	June 24	40			100	60	80.61	1,504.4
May 7	June 1	July 14	44	Feb. 8, 1911	209	100	66	84.51	1,826.4
June 18	July 5	Aug. 5	32	Feb. 4, 1911	183	104	73	88.09	1,442.9

The larva (Tables XX–XXI).—The larvæ of this tick have been found to live at least 215 days. The lot upon which this record was based hatched September 24, 1909. Fifty were still alive April 27, 1910. Other lots hatched in midsummer were found to live nearly as long as the one cited. Larvæ may drop engorged as soon as the fourth day after application to a host, while some may remain on the host 16 days and even then not become fully engorged. Although no engorgements were obtained from two or three lots of larvæ applied to bovines and guinea pigs, most of the lots tested attached readily and a large percentage of them engorged. Attachment was found to take place usually within an hour after the time of application to a host. Many specimens were found detached from the host when they were from one-fifth to two-thirds engorged. This premature dropping is probably due to the ease with which they are displaced by the host animal after they have become partially engorged.

TABLE XXI.—*Engorgement of larvæ of Ixodes kingi.*

Date larvæ applied.	Host.	Number.	Larvæ dropped engorged—days following application.										Total number dropped.	State of engorgement.
			4	5	6	7	8	9	13	14	15	16		
Sept. 15, 1909	Guinea pig.	120	0	11	51	25	8	5	....	....	....	....	100	One-half to fully.
Oct. 1, 1909	Rabbit.....	13	1	1	1	....	....	....	....	....	....	....	3	....
Oct. 28, 1909	Bovine.....	100	4	7	15	5	6	....	....	....	....	....	37	One-half to fully.
Nov. 4, 1909	.....do......	100	27	31	6	2	....	....	....	....	....	....	66	....
Nov. 16, 1909	.....do......	100	0	(1)	25	5	2	....	....	....	....	....	32	....
Jan. 14, 1910	Guinea pig.	110	0	0	0	6	0	0	2	....	....	....	8	One-half to two-thirds.
Sept. 28, 1910	.....do......	40	0	0	0	0	0	0	0	11	0	2	13	One-fifth to fully.
	Total.	583	....	....	....	....	....	....	....	....	....	....	259	

[1] The larvæ which dropped on this date were included with those which dropped on the following day.

The larval molting period varies greatly, as was shown in experiments in which 54 individuals were observed, and seems to be governed mainly by temperature conditions. The shortest molting period observed was 27 days; the longest, 163 days. The mean temperature during these two periods was 74.43 °F. and 59.65° F., respectively. A total effective temperature of 821.1° F. appears to be required for this transformation. The large percentage of mortality during molting in some of the lots was probably due in part to the fact that a considerable number of individuals was not fully engorged when detached from the host. During summer, when the molting period is shorter, the mortality would probably be smaller, as the effect of drying out would not be so great. Undoubtedly humidity is an important factor, at this stage of their development.

The nymph (Tables XXII–XXIII).—Of 20 nymphs which molted to larvæ between January 29 and April 2, 1910, 16 were put on hosts during March and April. The last individual of the four remaining died between June 9 and July 19, 1910. Thus the longevity of these 4 individuals was between 68 and 171 days. Another lot of 8 nymphs, which molted from larvæ between March 22 and April 4, 1910, died between June 9 and July 19, 1910, thus living for a period of 66 to 119 days. The minimum nymphal engorgement period recorded was 5 days. In one instance a nymph remained on the host 66 days, at the end of which time it was accidentally detached when only two-thirds engorged. Attachment was usually found to take place soon after application, but occasionally nymphs remained in proximity to a host for 36 hours before attaching. The readiness with which attachment takes place and the rate of engorgement appear to depend to some extent upon the vitality of the individuals when applied. If nymphs are weak when applied to a host they are usually slow in attaching, and frequently many die on the host before becoming engorged to any extent. Guinea pigs and bovines were the only hosts upon which nymphs were placed for engorgement in our experiments.

TABLE XXII.—*Engorgement of nymphs of Ixodes kingi.*

Date nymphs applied.	Host.	Number.	Number attached.	Nymphs dropped—days following application.					Total number dropped.	State of engorgement.
				5	7	15	16	66		
Oct. 25, 1909	Bovine........	1	1	......	......	......	......	1	1	Two-thirds.
Nov. 11, 1909	.....do........	5	4	......	......	1	2	......	3	Fully.
Mar. 29, 1910	Guinea pig...	8	4	......	......	......	1	......	1	Four-fifths.
Apr. 14, 1910	Bovine........	1	1	1	......	......	......	......	1	Fully.
Apr. 19, 1910	.....do........	8	4	......	1	1	......	......	2	Three-fourths to fully.
	Total..	23	....	......	......	......	......	......	8	

Of a large number of nymphs applied to hosts only 3 were brought to the adult stage. The records on these were made during April, May, and June, 1910. The molting periods for these 3 individuals, all of which were females, were 29, 33, and 34 days, respectively. An average daily mean temperature of 73.29° F. was recorded during the minimum molting period and a total effective temperature of 878.4° F. was accumulated.

TABLE XXIII.—*Molting of engorged nymphs of Ixodes kingi.*

Date engorged nymphs applied.	Host.	Number.	Engorged nymphs molted—days following dropping.			Number molted.			Temperature from dropping to date first tick molted.		
			29	33	34	Male.	Female.	Total.	Maximum.	Minimum.	Average daily mean.
									°*F.*	°*F.*	°*F.*
Apr. 19, 1910	Bovine....	1	......	......	1♀	0	1	1	90.0	51.50	71.87
Apr. 26, 1910	...do......	1	1♀	......	......	0	1	1	90.0	58.50	73.29
May 4, 1910	...do......	1	......	1♀	......	0	1	1	100.0	59.00	76.34
	Total...	3	......	......	......	......	3	3			

The adult.—One individual of a lot of 3 females which molted between May 23 and June 6, 1910, lived about 104 days. One partially engorged female lived 102 days after being removed from a host on September 20, 1909. This tick appeared to be killed by the cold. Owing to the fact that very little material was reared to the adult stage and both sexes were not obtained at the same time, no records of engorgement were obtained. One female put on a guinea pig attached in a few hours and died on the host during the second day after application. This tick appeared to take some blood prior to its death.

No observations have been made on mating. Very few males have been collected in nature as compared with the number of females taken. Making allowance for the fact that some collectors may have overlooked the males, it appears that females are much more abundant on hosts than are males.

The engorged females are usually well covered with a yellowish waxy substance, apparently secreted on all parts of the less chitinized integument. This substance frequently accumulates in considerable masses around the capitulum and genitalia. The engorged females are almost globular, and the legs are delicate and scarcely touch the surface upon which the female lies. Movement of the engorged females is therefore practically impossible.

LIFE CYCLE.

Larvæ may live for at least 215 days. They may engorge in 4 days and molt as soon as the ninth day after dropping. The longest molting period recorded was 163 days. A total effective temperature of at least 822° F. appears necessary for this molt. Nymphs may live for at least 66 days in summer and probably longer in winter. They may engorge as soon as the fifth day after application and molt as soon as the twenty-ninth day after dropping. A total effective temperature of 878.4° F. is required for the transformation to adult. The length of the engorgement period of females has not been determined. The shortest preoviposition period was 19 days and the longest 65 days. Deposition may continue for 34 days and as many as 4,706 eggs be deposited. Eggs may hatch as soon as 29 days after deposition and appear to require a total effective temperature of 1,109° F. for incubation.

All stages seem to be most numerous on hosts in midsummer, although we have specimens collected from March to November. Further investigation will probably show them to be present on hosts in greater or less numbers throughout the year.

ECONOMIC IMPORTANCE.

This tick has never been recorded as a parasite of man or of domestic animals other than the dog, and since it seldom occurs in great numbers on this host it appears to be of practically no economic importance.

NATURAL CONTROL.

No natural enemies of this species have been recorded. Eggs in a bunch of about 100 which were exposed to the sun on the ground for about 3 hours all shriveled and failed to hatch. During this period the highest atmospheric temperature was 110° F. and the highest soil surface temperature was 133° F.

Genus **HÆMAPHYSALIS** Koch.

Two species of the genus Hæmaphysalis occur in the United States both of which are quite widely distributed. One of the two (*Hæmaphysalis chordeilis*) is of economic importance on account of its habit of attacking turkeys. The life history and habits of 3 exotic species have been studied, namely, *H. leachi*, the active agent in South Africa in the transmission of canine piroplasmosis, by Lounsbury (1902, 1904, 1905), *H. proxima* in Brazil by Rohr (1909), and *H. punctata*, which has been found by Stockman (1908) to transmit bovine piroplasmosis. This latter species has recently been reported by Hadwen (1910) to occur in Manitoba. It must have been introduced from abroad, probably on cattle from England, where it is a very common pest. All three of these foreign species, as well as the two species (*H. leporis-palustris* and *H. chordeilis*) which have been studied by us drop from the host for both molts. One of the authors (Hooker 1909*a*, pp. 252–253) was led to believe that this species molts on the hosts on account of molted skins of larvæ being found on the heads of quail associated with larvæ and nymphs belonging to the genus Hæmaphysalis. We have since reared *H. chordeilis* and as we have had considerable numbers of both the larvæ and nymphs to drop from the hosts engorged and then molt, we must conclude that the skins found on the quail were shed by individuals of some other bird-infesting species.

THE RABBIT TICK.

Hæmaphysalis leporis-palustris Packard.

The rabbit tick (*Hæmaphysalis leporis-palustris* Packard) is so named from the fact that it is the most widely distributed and common tick which attacks the rabbit in the United States.

DESCRIPTIVE.

Adult (Pl. VII, figs. 4–6).—Males from 1.6 by 1 mm. to 2.25 by 1.25 mm. Females, unengorged, from 2.25 by 1.25 mm. to 2.5 by 1.5 mm.; engorged, from 6 by 3.5 by 2.5 mm. to 11.3 by 7.5 by 5.3 mm.; males and females very dark brown or black in color with no light markings; engorged females slate color.

Nymph (Pl. VII, figs. 2, 3).—Unengorged, about 1.33 by 0.8 mm., dark reddish brown; engorged, 2.5 by 1.75 mm., dark bluish gray to almost black; capitulum 0.218 mm. in length (from tip of palpi to postero-lateral angles of basis capituli); scutum 0.422 mm. long by 0.436 mm. wide.

Larva (Pl. VII, fig. 1).—Unengorged, about 0.534 by 0.385 mm.; dark smoky brown; scutum lighter in center; engorged, about 1.33 by 0.88 mm; ovoid, very dark brown to black, often with a pink tinge for some time after dropping; capitulum 0.164 mm. long (from tip of palpi to base of emargination of scutum); scutum 0.246 mm. long by 0.305 mm. wide.

Egg.—The average size for 10 eggs which were measured was 0.493 by 0.396 mm. Ellipsoidal, dark brown to black in color, shining, smooth.

HOST RELATIONSHIP.

The hares and rabbits are the principal hosts, especially of the adult stage. (*Lepus*) *Sylvilagus palustris* is the type host. We have collected the tick on about 7 species of rabbits, and have also taken the adults on robin, quail, meadowlark, and domestic cat. The immature stages have been taken in abundance on quail and meadowlark and in fewer numbers on chaparral cock and Brewer's blackbird. Immature stages of what are probably this species were taken on the thrush, field lark, jackdaw, blue jay, magpie, and pine squirrel. A single nymph was taken on a groove-billed ani at Victoria, Tamaulipas, Mex., and a larva, probably of this species, was taken on a small sparrow at Monterey, Mex. On rabbits the species is nearly always found attached to the ears, either inside or out. On birds the ticks are nearly always found upon the head, largely upon or about the crest. However, occasionally they attach on the neck and about the eyes and ears.

GEOGRAPHICAL DISTRIBUTION.

(Fig. 5.)

The type locality for this species is North Carolina. The species occurs in many States, from Massachusetts to California and Mexico. The States from which the species is recorded are Alabama, Arizona, Arkansas, California, Colorado, Florida, Idaho, Illinois, Kansas, Louisiana, Massachusetts, Minnesota, Montana, New Mexico, New York, North Carolina, Nevada, Oklahoma, Oregon, Tennessee, Texas, Virginia, Washington, and Wyoming. It has also been taken in Mexico. In western Texas, New Mexico, and Arizona the species is not commonly found, the rabbit Dermacentor being the tick ordinarily met with on rabbits. We have taken it in large numbers from rabbits in Montana and neighboring States.

LIFE HISTORY.

Observations on the biology of this species have been reported by Hunter and Hooker (1907) and by Hooker (1908, 1909).

The egg (Tables XXIV, XXV).—In one instance oviposition began on the third day after dropping. The mean temperature during this period beginning June 15, 1909, was 89.5°F. The longest preoviposition period observed was 15 days. This record was made on a well-engorged female collected March 7, 1910. The mean temperature for the period was 68.62° F. The average preoviposition period of 25 ticks observed during the spring and summer months was 8 days. The engorged female is usually comparatively small, due probably to the fact that it is confined to the smaller mammals and to bird hosts. Owing to its rather small size it deposits comparatively few eggs. Eight females were under observation. The largest number of eggs deposited by a single female was 2,240; the smallest

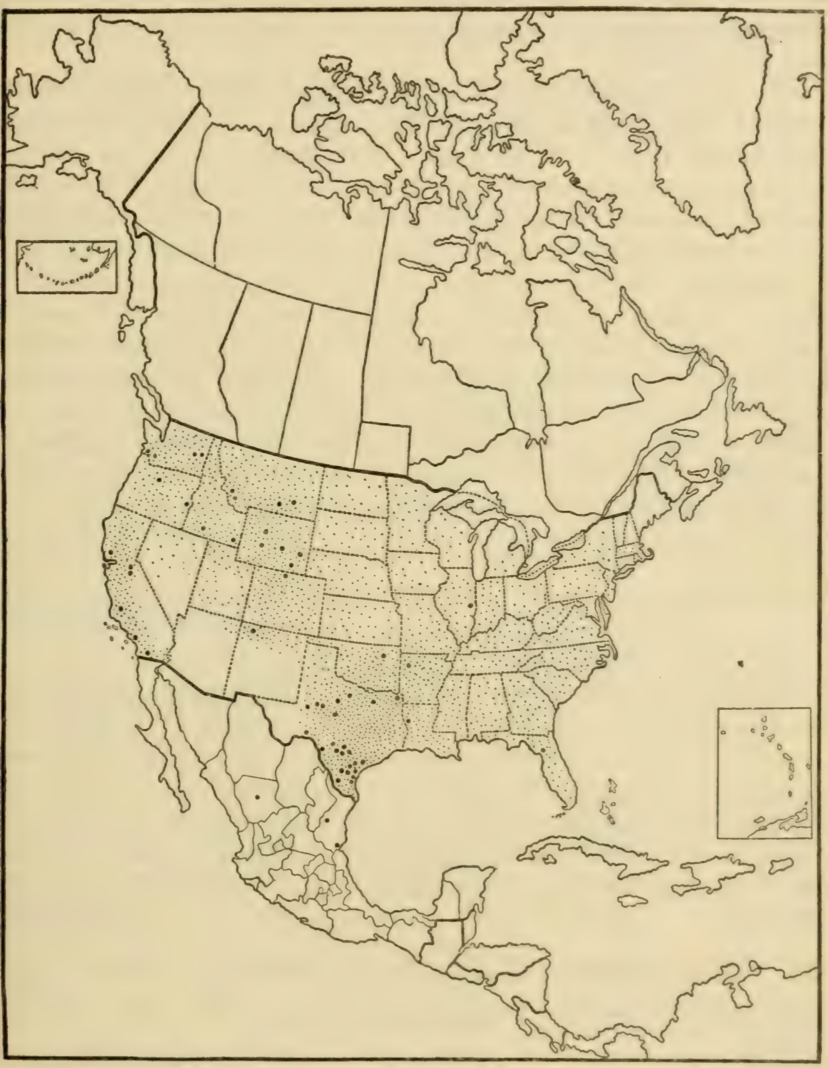


FIG. 5.—The rabbit tick, *Hæmaphysalis leporis-palustris:* Distribution in the United States. The large dots show localities where the species has been collected in our investigation. The small dots show the probable distribution of the species. (Original.)

number was 59, and the average number was 1,517. This maximum record was made by a fully-engorged female collected on a rabbit May 7, 1909. This was the largest engorged female seen by us, measuring 11.3 by 7.5 by 5.3 mm. Deposition began on the seventh day after collection and continued for 20 days. The largest number of eggs deposited during one day was 303, which occurred on the first day of oviposition.

The preoviposition period of the eight females ranged between 4 and 9 days, with an average of 6.4 days. The period of oviposition varied from 5 to 20 days. The female having the shortest oviposition period probably died prematurely. Death of the females usually took place on the day following the completion of egg laying. In one case it occurred on the fifth day after deposition ceased.

Eggs kept out of doors were, in one instance, found to hatch in 22 days. The mean temperature during this period was 90° F. and the total effective temperature 1,034° F. In the laboratory the incubation period has been found to be as short as 23 days for eggs deposited in June. During this period the mean temperature was 82° F., an effective temperature of about 902° F. being required for hatching. The longest incubation period observed in about 25 lots of eggs deposited during the spring and summer was 40 days.

TABLE XXIV.—*Incubation and longevity of larvæ of Hæmaphysalis leporis-palustris.*

Eggs deposited.	Hatching began.	Minimum incubation period.	All larvæ dead.	Larval longevity.	Temperature during incubation period.			
					Maximum.	Minimum.	Average daily mean.	Total effective.
		Days.		*Days.*	*°F.*	*°F.*	*°F.*	*°F.*
May 20–23, 1906	June 20	32	Mar. 5, 1907	258				
May 24–29, 1906	June 23	31	do	255				
Sept. 2–5, 1906	Sept. 26	25	May 11, 1907	217				
Sept. 4, 1907	Sept. 27	24	Apr. 13, 1908 (several alive).	199+	102.0	50.0	78.72	821.5
Sept. 7–9, 1907	Sept. 30	24	Mar. 17, 1908 (one alive).	168+	102.0	50.0	77.3	788.5
June 29, 1908	July 21	23	Sept. 21, 1908	62	94.0	70.5	82.25	902.75
May 6, 1909	June 8	34	Jan. 22, 1910 (one alive).	228+	89.5	59.0	81.49	1,308.75
June 18, 1909 [1]	July 9	22	Sept. 18–28, 1908	71–80	102.0	81.0	90.0	1,034.00
Apr. 14, 1910	May 23	40	July 19 to Aug. 20, 1910.	57–89	90.0	51.5	70.91	1,116.50
May 7, 1910	June 9	34	do	40–72	100.0	59.0	77.29	1,285.75
June —, 1910	July 14		Feb. 3, 1911	204				

[1] This lot was kept out of doors.

The larva (Tables XXIV, XXV).—The longevity of the larvæ has been found to be as great as 258 days under favorable conditions. The larvæ which survived for this period hatched on June 20 and thus passed through the summer months, which are the most unfavorable to long survival. Many lots of larvæ which hatched early in the summer of 1909 died in about two months. The excessive heat during August of that year was at least partially responsible. Engorged larvæ have dropped from rabbits as soon as the fourth day following attachment, but on a bovine 6 days was the shortest period of engorgement. The greatest number drop from the fifth to the eighth day, 10 days being the longest time required for engorgement.

TABLE XXV.—*Engorgement of larvæ of Hæmaphysalis leporis-palustris.*

Date larvæ applied.	Host.	Larvæ dropped engorged—days following application.										Total number dropped.
		1	2	3	4	5	6	7	8	9	10	
Sept. 30, 1907	Rabbit	0	0	0	0	25	27	33	7	5	1	98
Oct. 29, 1907	...do	0	0	0	5	77	71	29	5	1	4	192
Nov. 15, 1907	Bovine	0	0	0	0	19	75	27	11	2	0	134
Mar. 11, 1908	...do	0	0	0	0	0	13	19	4	0	0	36
Mar. 19, 1908	...do	0	0	0	0	11	131	115	24	0	0	281

The molting of engorged larvæ was observed in 384 cases. Larvæ which dropped in March at a mean temperature of 68.7° F. molted in 18 days, an effective temperature of 463° F. having been required. The longest period passed before molting was for 2 larvæ which dropped November 22, 1907, and molted 134 days later. The mean temperature during this period was 61.98° F. Unfortunately our records do not include individuals which engorged during the summer months.

The nymph (Tables XXVI, XXVII).—The greatest nymphal longevity observed was 342 days. This record was made on two nymphs which were collected on a rabbit on June 19, 1909, by Mr. W. V. King. One of a few nymphs which molted from larvæ April 19, 1908, lived for 307 days. A number of other lots of ticks, which were observed from the time they molted to nymphs, lived from 78 to 246 days. The longevity of a number of lots of collected individuals, which had become from slightly to one-half engorged, was from 34 to 334 days. The minimum engorgement period of nymphs which we have observed was 4 days, the last ticks dropping on the eighth day after application.

TABLE XXVI.—*Engorgement of nymphs of Hæmaphysalis leporis-palustris.*

Date nymphs applied.	Host.	Nymphs dropped engorged—days following application.										Total number dropped.
		1	2	3	4	5	6	7	8	9	10	
Oct. 29, 1907	Rabbit	0	0	0	0	0	2	1	0	0	0	3
Feb. 25, 1908	Bovine	0	0	0	0	0	1	0	1	0	0	2
Apr. 4, 1908	...do	0	0	0	0	0	3	6	2	0	0	11
June 2, 1908	...do	0	0	0	5	24	14	2	0	0	0	45
May 22, 1909	Rabbit	0	0	0	1	0	0	0	0	0	0	1

Nymphs which dropped June 8, 1908, and were kept at a mean temperature of 80° F. commenced molting on the fourteenth day after dropping. A total effective temperature of 486° F. accumulated during this period. When the mean temperature was 58.34° F. molting began on the eighty-ninth day after dropping. The longest period from dropping to molting which we have observed was 124 days. The last three lots of ticks, the molting of which is recorded in the following table, were collected from wild hosts and were not all fully engorged. This may have tended to lengthen slightly the molting period of some of the individuals.

The nymphal molting period of the two sexes is practically the same. Our observations indicate that a very large percentage of the engorged nymphs reach the adult stage even when dropping takes place in the winter.

TABLE XXVII.—*Molting of engorged nymphs of Hæmaphysalis leporis-palustris.*

Date engorged nymphs dropped.	Host.	Number.	Engorged nymphs molted—days following dropping.																			
			13	14	15	16	25	26	27	29	30	48	49	53	58	84	85	89	94	96	97	98
Nov. 4,07	Rabbit....	1	0	0	0	0	0	0	0	0	0	0	1♂	0	0	0	0	0	0	0	0	0
Nov. 5,07	...do.......	1	0	0	0	0	0	0	0	0	0	1♀	0	0	0	0	0	0	0	0	0	0
Apr. 10,08	Bovine....	3	0	0	0	0	0	0	1♀	2♂	0	0	0	0	0	0	0	0	0	0	0	0
Apr. 11,08	...do.......	6	0	0	0	0	1♀	0	1♂	1♀	1♀	0	0	0	0	0	0	0	0	0	0	0
Apr. 12,08	...do.......	2	0	0	0	0	0	1♂ 1♀	0	0	0	0	0	0	0	0	0	0	0	0	0	0
June 6,08	...do.......	5	0	1♂	1♂ 1♀	2♂	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
June 7,08	...do.......	24	0	2♂ 5♀	4♂ 8♀	2♂ 2♀	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
June 8,08	...do.......	14	1♂ 1♀	3♂ 2♀	4♀	1♂	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
June 9,08	...do.......	2	0	0	1♂	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nov. 10,08	Quail......	2	0	0	0	0	0	0	0	0	0	0	0	1♀	1♀	0	0	0	0	0	0	0
Nov. 25,09	Rabbit....	27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0	0	2	2
Dec. 29,09	Chaparral cock.....	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1♂	1♂ 1♀	1♂	1♀	0	0
Total	....	93	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	..

Date engorged nymphs dropped.	Host.	Number.	Engorged nymphs molted—days following dropping.					Number molted.			Temperature from dropping to date first tick molted.		
			100	104	112	113	124	♂	♀	Total.	Maximum.	Minimum.	Average daily mean.
											°F.	°F.	°F.
Nov. 4,07	Rabbit....	1	0	0	0	0	0	1	0	1	....	....	....
Nov. 5,07	...do.......	1	0	0	0	0	0	0	1	1	....	....	....
Apr. 10,08	Bovine....	3	0	0	0	0	0	2	1	3	83.0	47.0	68.84
Apr. 11,08	...do.......	6	0	0	0	0	0	1	3	4	83.0	47.0	68.98
Apr. 12,08	...do.......	2	0	0	0	0	0	1	1	2	83.0	47.0	70.07
June 6,08	...do.......	5	0	0	0	0	0	4	1	5	91.5	69.0	80.52
June 7,08	...do.......	24	0	0	0	0	0	8	15	23	91.5	69.0	80.57
June 8,08	...do.......	14	0	0	0	0	0	5	7	12	91.5	69.0	80.39
June 9,08	...do.......	2	0	0	0	0	0	1	......	2	91.5	69.0	80.55
Nov. 10,08	Quail......	2	0	0	0	0	0	0	2	2	82.0	34.0	59.15
Nov. 25,09	Rabbit....	27	2	1	2	1	2	......	......	24	83.0	17.0	58.34
Dec. 29,09	Chaparral cock.	6	0	0	0	0	0	3	2	5	87.0	17.0	61.62
Total	....	93	....	....	....	....	....	26	33	84	....	....	....

♂=Male. ♀=Female.

The adult (Table XXVIII).—The longevity of adults of this species is probably equal to that of any other ixodid tick. In a tube which contained a lot of about 24 adults which molted from nymphs shortly before September 29, 1909, the last individual, a female, died May 10, 1911, having lived at least 588 days. A male in another lot which molted to adults between February 22 and March 29, 1910, lived for 403 days. In a third test a female in a lot which molted between March 23 and April 4, 1910, died on May 10, 1911, after a period of 401 days. One male in a lot of about 6 males and females which became adult April 15, 1908, lived for 395 days. The longevity of several other lots of ticks upon which the date of molting was recorded ranged between 109 and 355 days. These lots became adult in the spring and early summer months. A longevity of from 17 to 167 days was observed in the case of 10 lots of adults collected on hosts during 1909 and 1910.

Considerable difficulty has been met with in getting females to engorge. Although males and females have attached in conspicuous places on the ears of tame rabbits, we have failed to observe them in copulation. A small female dropped in 17 days, but the only female which attained full size required three weeks for engorgement.

The last individual, the engorgement of which is recorded in the following table, was placed on the host without males. Mr. George Wolcott, who observed this engorgement, found that it attached in less than half an hour. It remained for at least three weeks before any appreciable engorgement took place. In the last three days engorgement was very rapid.

TABLE XXVIII.—*Engorgement of females of Hæmaphysalis leporis-palustris.*

Adults applied.	Host.	Female dropped engorged.	Period of attachment.	Size engorged.
			Days.	
July 8, 1908	Rabbit	July 25	17	6 by 3.5 by 2.5 mm.
Do	do	July 29	21	10 by 6 by 3 mm.
Do	do	Aug. 3	26	Scratched off.
Jan. 14, 1911	do	Feb. 18	35	Fully engorged.

LIFE CYCLE.

This tick may commence to oviposit as soon as the fourth day after leaving the host. The largest number of eggs deposited by an individual was 2,240. The eggs have been found to hatch in 22 days. A total effective temperature of at least 902° F. is required for incubation. Larvæ have been found to live 258 days. They may engorge and drop in 5 days after attaching to a host. Molting of larvæ may begin in 18 days. A total effective temperature of 463° F. appears to be required for the transformation to nymphs. Nymphs may live for 342 days. They may engorge in 4 days after attachment and begin molting 13 days after dropping. A total effective temperature of about 486° F. is required to produce this transformation. Adults may live for 588 days without food. Both sexes have been found together in abundance on wild hosts, but copulation has not been observed in ticks reared experimentally. Females may drop engorged in 17 days after attachment to a host.

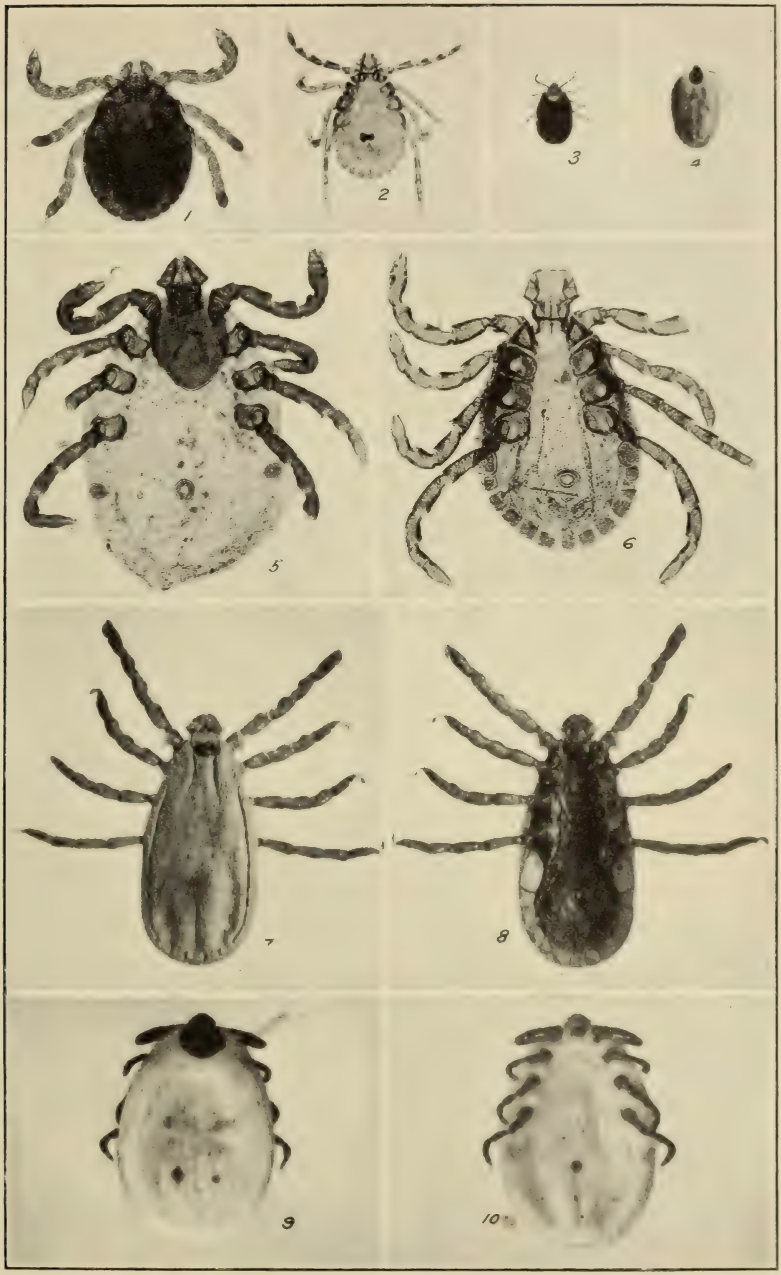
The three stages of the rabbit tick have been taken from hosts in nature during all seasons of the year. We have found the immature ticks in great numbers on ground-inhabiting species of birds in the fall and winter; they may, however, be equally numerous in the summer.

ECONOMIC IMPORTANCE.

On account of the fact that this tick confines its attack to rabbits and wild birds, it is of no importance economically. In a few instances the species has been known to become so abundant on wild rabbits as to render them so weak that they could be easily killed by their enemies. Mr. W. V. King killed two snowshoe rabbits (*Lepus bairdi*) at Florence, Mont., on April 3, 1910, which were infested with 1,033 ticks. Many of these were fully engorged females. The large number of specimens found on quail and meadowlarks leads us to believe that in some cases the young of these hosts may be killed by tick attack.

NATURAL CONTROL.

The bird hosts of the rabbit tick undoubtedly destroy a considerable number of them, although they also serve as disseminators of the species. As has been stated, rabbits have been observed by us to devour engorged ticks and no doubt some specimens are injured by the scratching of this host. The smaller birds, such as sparrows, and certain reptiles and batrachians, are also probably of some importance in the destruction of this tick. It is known that this species is parasitized in the nymphal stage by a chalcidid. This parasite (*Ixodiphagus texanus*), the first recorded as having been reared from a tick, was described by Dr. L. O. Howard (1908) from individuals reared at the tick laboratory from engorged nymphs collected by Mr. J. D. Mitchell in Jackson County, Tex. A single specimen in each of two different lots of engorged nymphs was found to be parasitized by this insect. One of these lots was collected March 10, 1907, on a cottontail rabbit and the other May 1, 1907, on a jack rabbit. Subsequent collections in that locality have failed to reveal other parasitized specimens.



THE RABBIT TICK, HÆMAPHYSALIS LEPORIS-PALUSTRIS, AND THE BIRD TICK, HÆMAPHYSALIS CHORDEILIS.

Hæmaphysalis leporis-palustris: Fig. 1.—Unengorged larva. Fig. 2.—Unengorged nymph. Fig. 3.—Engorged nymph. Fig. 4.—Engorged female. Fig. 5.—Partially engorged female (balsam mount). Fig. 6.—Male (balsam mount). *Hæmaphysalis chordeilis:* Fig. 7.—Male, dorsal view. Fig. 8.—Male, ventral view. Fig. 9.—Engorged nymph, dorsal view. Fig. 10.—Engorged nymph, ventral view. (Original.)

THE BIRD TICK.

Hæmaphysalis chordeilis Packard.

The common name of this species is applied on account of the fact that birds are its principal hosts.

DESCRIPTIVE.

Adult (Pl. VII, figs. 7, 8).—Males from 2.8 by 1.5 mm. to 2.9 by 1.6 mm. Scutum light gray in color, shading into amber anteriorly; marginal strip bluish white; legs and capitulum amber. Females, unengorged, from 2.8 by 1.4 mm. to 2.9 by 1.8 mm.; engorged, about 9 by 6.6 by 4 mm.; reddish brown in color when unengorged, scutum without markings.

Nymph (Pl. VII, figs. 9, 10).—Unengorged, 1 by 0.65 to 1.4 by 0.72 mm.; light brown in color, scutum darker; engorged, about 2.43 by 1.79 mm.; color dark gray. Capitulum 0.217 mm. in length (from tip of palpi to base of emargination of scutum); scutum 0.446 mm. long by 0.447 mm. wide.

Larva.—Unengorged, from 0.552 by 0.402 to 0.574 by 0.430 mm.; body ovoid, yellowish brown; engorged, from 1.4 by 0.8 by 0.6 mm. to 1.5 by 1 by 0.6 mm.; abdomen slate color. In most cases three distinct longitudinal white lines are to be seen on the dorsum; shield very dark brown, almost black posteriorly, shading to a pale yellow-brown anteriorly. The legs and mouthparts are translucent yellowish brown. Capitulum 0.125 mm. in length (from tip of palpi to base of emargination of scutum), scutum 0.240 mm. long by 0.308 mm. wide.

Egg.—No eggs of this species have been seen by us.

HOST RELATIONSHIP.

The type host of this species is the nighthawk. The species has a comparatively wide range of bird hosts. Those species which are more or less ground-inhabiting seem to be more frequently infested. The immature stages of this tick are frequently found in large numbers, usually attached to the heads of the hosts. They are very frequently associated on the hosts with the immature stages of *Hæmaphysalis leporis-palustris*. The following birds have been found to act as hosts: meadowlark, jackdaw, red-winged blackbird, marsh hawk, quail, and domestic turkey. Mr. Banks mentions having seen a nymph, probably of this species, from the killdeer. The examinations of birds in Texas indicate that the meadowlark is by far the most commonly infested host. We also have a fairly reliable record of three adults of this species having been taken from a prairie chicken in Texas. As has been stated, the ticks are usually found to attach on the top of the head. They are also found around the eyes and ears and occasionally under the bill.

GEOGRAPHICAL DISTRIBUTION.

The type locality for this species is Milton, Mass. Specimens have also been taken at Norwich and Taftsville, Vt. Most of the other collections were made in Victoria and Refugio Counties in Texas by Mr. J. D. Mitchell. We have one authentic record from D'Hanis, Medina County, Tex., and one of the authors (Hooker) collected larvæ and nymphs which he thought were this species at Grand Cane, La., and Hawthorn and Quincy, Fla. It is very probable that this tick has a wide range of distribution, but owing to the fact that little collecting has been done upon birds in other localities, the range of the species is not fully known.

LIFE HISTORY.

Little has been published on the biology of this tick. Hooker (1909*a*) reports the finding of molted larval skins attached to the head of a meadowlark. These were associated with engorged larvæ of this genus and it was thought that they might be exuvia of the bird tick.

The egg.—Owing to the difficulty in securing engorged females no records have been made upon preoviposition and oviposition periods. The number of eggs deposited by this species has not been determined. Dr. Philip B. Hadley, of the Rhode Island Agricultural Experiment Station, kindly sent Mr. Nathan Banks a large number of larvæ which hatched about August 15 from eggs deposited by a number of engorged females collected on turkeys at Norwich, Vt., June 28, 1909. These larvæ were forwarded to us at Dallas, Tex., by Mr. Banks.

The larva (Tables XXIX–XXX).—The longevity of the larva of this species has not been definitely determined. Larvæ of one lot which hatched about August 15 lived at least 39 days. At the end of that period they were placed on hosts.

As is indicated in Table XXIX, larvæ have been engorged on rabbits and guinea pigs. Two attempts to engorge them on chickens failed, though a few were found to attach. Attachment was found to take place very soon after the larvæ were applied, usually within 5 to 30 minutes. Dropping began as soon as the fifth day after attachment. The longest period of engorgement observed was 12 days. The weighted average time from application to dropping in the case of the 33 larvæ engorged was 7.5 days.

TABLE XXIX.—*Engorgement of larvæ of Hæmaphysalis chordeilis.*

Date larvæ applied.	Host.	Number.	Larvæ dropped engorged—days following application.								Total number dropped.	State of engorgement.
			5	6	7	8	9	10	11	12		
1909.												
Sept. 7	Rabbit........	85	6	9	2	2	0	2	0	0	21	Fully.
Sept. 7	Hen............	28	0	0	0	0	0	0	0	0	0	
Sept. 17	Guinea pig....	75	....	....	....	1	....	1	....	....	2	Fully.
Sept. 18	Hen............	15	0	0	0	0	0	0	0	0	0	
Sept. 22	Rabbit........	7	0	0	0	1	0	1	1	0	3	Two-thirds to fully.
Sept. 24	.....do.........	15	0	0	0	2	3	1	0	1	7	Two-thirds to fully.
	Total...	225	....	....	....	....	....	....	....	....	33	

At a mean temperature of 79.05° F. molting began on the fourteenth day after dropping. When the mean temperature fell to 53.98° F. 76 days elapsed before molting began. This and the other long molting period given in the table were recorded on larvæ collected from wild hosts, and although the state of engorgement of the ticks was not recorded, there is little doubt that they were not fully engorged. This would tend to lengthen the molting period as has been found true in all observations made by us on this point. A total effective temperature of 505° F. appears to be required for this transformation.

TABLE XXX.—*Molting of engorged larvæ of Hæmaphysalis chordeilis.*

Date engorged larvæ dropped.	Host.	Number of larvæ.	Engorged larvæ molted—Days following dropping.														Temperature from dropping to date first tick molted.		
			14	15	16	17	18	19	21	26	32	42	67	76	92	Total number molted.	Maximum.	Minimum.	Average daily mean.
1909.																	°*F.*	°*F.*	°*F.*
Sept. 12	Rabbit.	6	...	2	1	...	...	...	...	...	...	...	...	...	...	3	98.50	59	79.84
Sept. 13	...do....	9	1	...	...	1	2	...	...	1	...	1	...	...	...	6	96.50	59	79.05
Sept. 14	...do....	2	...	1	...	...	...	...	...	...	...	...	...	...	...	1	95.50	56	77.28
Sept. 17	...do....	2	...	1	...	...	1	...	...	...	...	...	...	...	...	2	95.50	56	76.75
Sept. 25	...do....	1	...	...	...	...	...	...	...	...	1	...	...	...	...	1	92.50	51	72.38
Sept. 30	...do....	1	...	...	...	...	...	...	...	1	...	...	...	...	...	1	92.50	51	72.77
Oct. 2	...do....	2	...	...	...	...	...	1	...	1	...	...	...	...	...	2	92.50	52.50	73.80
Oct. 3	...do....	3	...	...	...	...	...	...	1	...	...	...	...	...	...	1	92.50	52	72.88
Nov. 16	....	6	...	...	...	...	...	...	...	...	...	...	...	1	1	2	79	20	53.98
Nov. 25	Meadowlark...	4+	...	...	...	...	...	...	...	...	...	...	[1] 4	...	...	4	79	20	52.96
	Total..	36+	...	...	...	...	...	...	...	...	...	...	...	...	...	23	....	....	....

[1] Three of these molted before Jan. 31, 1910, and one on that date.

The nymph (Table XXXI).—On account of the sparsity of material at hand, our records on the longevity of nymphs are fragmentary. One nymph which molted from a larva about January 22, 1910, was alive on April 6, 1910, when it was put on a host. This individual had lived 74 days, which is the longest period recorded by us. One nymph which molted February 15, 1910, died 16 days later. Two other lots lived from 16 to 55 days, at the end of which time they were put on hosts.

Nymphs were found to attach readily to a bovine host very soon after being applied. Attempts to get collected nymphs which were partially engorged to reattach to cattle and guinea pigs were not successful. Similar results were obtained when attempts were made to attach to rabbits and cattle nymphs which had very recently molted from the larval stage. In the three lots of nymphs the engorgement of which is recorded in the accompanying table the shortest period of engorgement was 5 days, the longest 8 days, and the weighted average 6.9 days. All of the specimens were fully engorged when they dropped.

Table XXXI.—*Engorgement of nymphs of Hæmaphysalis chordeilis.*

Date nymphs applied.	Host.	Number.	Nymphs dropped—Days following application.				Total number dropped.
			5	6	7	8	
1909.							
Nov. 3	Bovine	4			3	1	4
Nov. 30	do	4				2	2
Nov. 28, 29	do	5	1	2			3

The shortest molting period for nymphs in the 13 cases observed was 26 days. During this period the mean temperature was 68.05° F. and the total effective temperature 651° F. The longest molting period was 186 days at a mean temperature of 60.54° F. The lots of collected individuals varied from one-tenth to fully engorged. None of the specimens under one-half engorged was observed to molt to adults. The temperatures given are those recorded at the Dallas laboratory from the date the ticks were collected to the date when the first tick molted.

The adult.—Of a lot consisting of 4 males and 3 females which became adult between May 5 and 10, 1910, 2 individuals of each sex were placed on hosts, 2 males and 1 female being kept for a longevity test. One male and the female died on August 18, 1910, having lived about 100 days. The last male lived until March 11, 1911, or a period of 305 days. A female in another lot was found to live between 131 and 166 days after molting, and in a third lot a male lived between 97 and 127 days. Unengorged adults remain inactive for long periods when kept in a tube, and it is sometimes difficult to induce them to crawl. One female which was fully engorged but not fertilized lived 172 days, no eggs being deposited.

A male and a female were placed on a bovine April 30, 1910. The female was found to be attached when examination was made 6 hours later. The male failed to attach as did also two other males applied several days afterwards. The female, however, began to fill with blood and 19 days later dropped rather well engorged. This female did not deposit eggs but lived 172 days, as noted above. Attempts to get adults to attach to a hen were unsuccessful.

No observations have been made on mating, nor have the periods of preoviposition and deposition been determined. The number of eggs deposited has not been determined as yet.

LIFE CYCLE.

Larvæ may live for at least 39 days and probably much longer; they engorge in from 5 to 12 days and molt in the summer as soon as the fourteenth day after dropping and as long as the ninety-second day after dropping in the winter. A total effective temperature of 505° F. is required for this transformation. One nymph lived for at least 74 days. Nymphs may become engorged in 5 days during the last of November. Molting to adults occurred in as short a period as 26 days after dropping and during the winter a molting period of 186 days was recorded. A total effective temperature of 651° F. appears to be required to produce the nymphal molt. Males may live 305 days and females as long as 131 days.

Most of our collections have been made between November and April. During this period all stages have been taken on wild bird hosts, the larvæ and nymphs being very abundant. No doubt they are present on hosts in Texas throughout the year. In Vermont, where the species has appeared as a pest to turkeys, adults and immature ticks were found in abundance in June.

ECONOMIC IMPORTANCE.

The bird tick has attracted attention as an economic species only in a few instances. In 1906 a specimen was received by the Bureau of Entomology from Taftsville, Vt., with the statement that it was found attacking a turkey. This species was not again heard of as a pest until June, 1909, when the attention of Dr. Philip B. Hadley, of the Rhode Island Agricultural Experiment Station, was called to a flock of young turkeys which were being killed by this tick at Norwich, Vt. The parasite appeared on turkeys on two farms in that locality. Dr. Hadley states that on one farm 40 out of a flock of 46 turkeys died before the ticks were finally destroyed by hand picking. Numerous adult and immature ticks were found to be attached to the hosts, principally on the necks of the birds. Dr. Hadley informed us that apparently none of these ticks was present in the vicinity of Norwich during 1910.

It is doubtful if these ticks ever become so numerous on wild birds as to cause their death, though they frequently appear in great numbers on quail and meadowlarks. Turkeys ranging over fields where wild birds are numerous are quite likely to become infested and thus bring the ticks into the poultry yards.

NATURAL CONTROL.

On account of the fact that this appears to be principally a bird-infesting species, there is undoubtedly a large mortality due to their destruction by the host.

ARTIFICIAL CONTROL.

This species has not been studied sufficiently to warrant any statement regarding control. It has been reported by Dr. Hadley that the ticks are exceedingly hard to kill by the application of such substances as kerosene and lard. He states that hand picking was the only method of control found to be effective against the ticks where they appeared as a pest on a farm at Norwich, Vt. A knowledge of the relation between the wild bird hosts and domestic turkeys may possibly suggest some preventive measure.

Genus **RHIPICEPHALUS** Koch.

Only one species of the genus Rhipicephalus occurs in the United States and that only in the extreme southern part of Texas. The genus, however, is a large one, as many as ten species being recorded by Howard (1908) as occurring in Africa alone. The members of this genus are also of considerable economic importance, five species being known to be active agents in the transmission of African coast fever, a highly fatal disease of cattle. One of these five also transmits biliary fever of horses, mules, and donkeys. A sixth species transmits ovine piroplasmosis in southern Europe, while in the Old World a seventh, the species which we have studied and consider here, transmits canine piroplasmosis.

Most of the species drop to pass their molts, but two, *R. evertsi* and *R. bursa*, pass the first molt while on the host.

Observations on the biology of the African species have been published by Lounsbury (1900b, 1905), Theiler (1905, 1909), and Howard (1909). Observations on *R. bursa* have been reported by Motas (1903).

THE BROWN DOG TICK.

Rhipicephalus sanguineus (Latreille) (*texanus* Banks).

The common name of *Rhipicephalus sanguineus* (brown dog tick) is taken from its color and the fact that the dog is its principal host.

DESCRIPTIVE.

Adult (Pl. VI, figs. 13–17).—Males from 2 by 1.25 to 3 by 1.5 mm. Females, unengorged, 1.5 by 1 mm. to 3 by 1.75 mm.; engorged, 6 by 4 by 1.5 mm. to 11 by 7 by 4.5 mm. The males and females are reddish brown, without markings, the legs being somewhat paler.

Nymph (Pl. VI, fig. 12).—Unengorged, about 0.94 by 0.57 mm.; engorged, 2.5 by 1.5 by 1 mm. to 3.5 by 2 by 1 mm. Color, unengorged, reddish brown; engorged, dark gray, some with a pink tinge and many whitish due to the engorgement of lymph; smooth, shining. Capitulum 0.244 mm. long (from tip of hypostome to base of emargination of scutum); scutum 0.451 mm. long by 0.462 mm. wide.

Larva (Pl. VI, figs. 10, 11).—Unengorged, about 0.457 by 0.328 mm.; engorged, about 1.5 by 0.88 mm. Color, unengorged, light brown; engorged, dark gray; capitulum 0.116 mm. long (from tip of hypostome to base of emargination of scutum); scutum 0.212 mm. long by 0.301 mm. wide.

Egg.—The average size of 10 eggs was 0.43 by 0.37 mm.; ellipsoidal, dark brown, shining, smooth.

HOST RELATIONSHIP.

Although this tick infests principally the dog it appears to attach to numerous hosts, among which the following have been reported: Fox, and other canines, cat, ox, horse, hare, dromedary, camel, sheep, goat, birds, and also one or two species of reptiles.

In extensive collections made by agents of this bureau in Texas and Mexico, however, the species has been taken from the dog only. Newstead reports that in Jamaica it is common on the ox as well as the dog and that it was also found on the horse. In one instance two slightly engorged nymphs attached between the fingers of one hand of one of the authors after he had been collecting specimens from dogs.

In regard to the position of attachment, Christophers, as well as the writers, has observed that the adults frequently attach to the inside of the dog's ears, even deep down in the meatus. Christophers, Nuttall, a correspondent of Newstead, and the writers have observed that they frequently attach between the toes and that they may be found there in clusters of 3 or 4. The writers have found the females to engorge to repletion between the toes of puppies. This position is readily accessible to the ticks and infestation may occur without being suspected, as even the engorged females are often obscured from view. Many larvæ and nymphs of this as well as other species attach and engorge in the little pocket on the posterior border of the ear. In the immature stages it appears to prefer to attach in the long hair on the neck rather than in the ears, the ticks frequently being found in cluster of a dozen or more. All three stages may, however, attach to almost any part of the body.

GEOGRAPHICAL DISTRIBUTION.

(Fig. 6.)

This species is probably the most widely distributed of all the ticks, at least of the ixodid ticks, even though largely limited to the Tropical and Subtropical regions. Portugal is the type locality of the species. In Europe it is also recorded from France, Italy, Sicily, Corsica, and Roumania; in Africa from Egypt, Algeria, Tunis, Nubia, Abyssinia, Zanzibar, German East Africa, Portuguese East Africa,

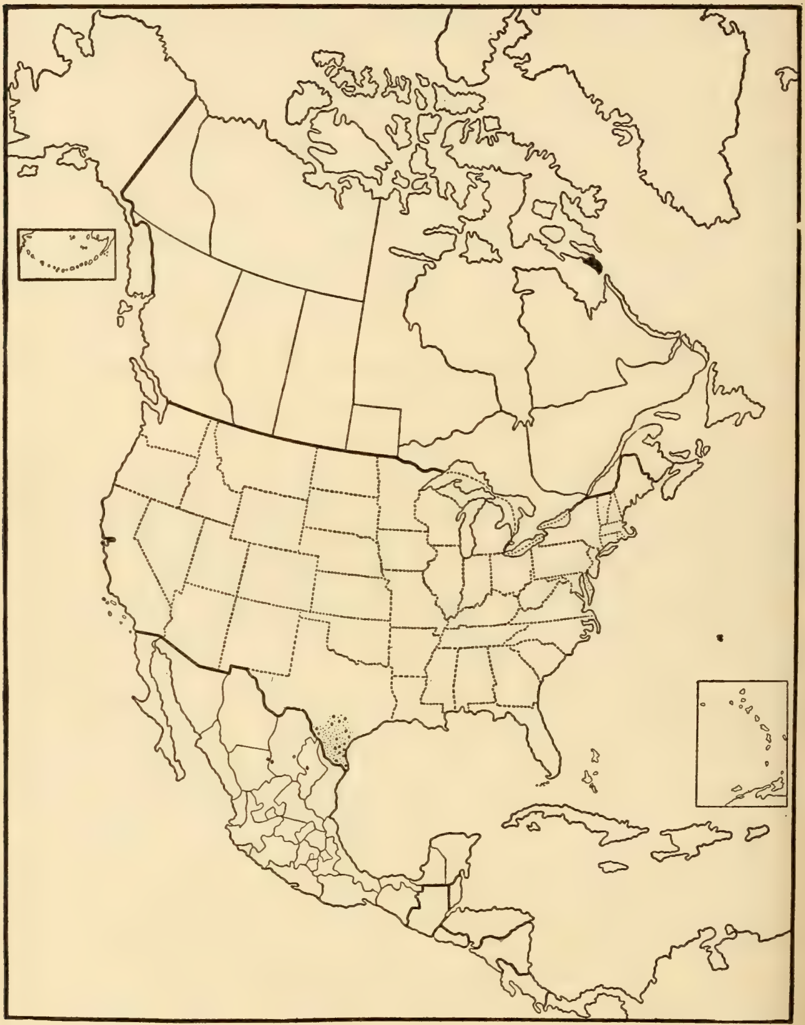


Fig. 6.—The brown dog tick, *Rhipicephalus sanguineus:* Distribution in the United States. The large dots show localities where the species has been collected in our investigation. The small dots indicat the probable distribution of the species. (Original.)

Transvaal, Natal, Cape Colony, Madagascar, German Southwest Africa, Kamerun, Togo, Congo, and Senegal; in Asia from Arabia, Persia, Malay Archipelago, India, and China. It has also been reported from Australia, the Philippines, and the Hawaiian Islands. In this country it has been commonly taken in southern Texas as far north as Jackson County and San Marcos in Hays County, and as far west as Del Rio. The species has been collected at several points in Mexico as far west as Torreon, in Panama, Colombia, Guiana, and Brazil, and undoubtedly occurs in all of the intervening countries. It occurs throughout the West Indian Islands, having been reported from Jamaica, Haiti, Antigua, and Dominica. Ticks from the West Indies, including Cuba, Haiti, and Curaçao Island, have been referred by Neumann to *R. bursa.*

LIFE HISTORY.

Observations on the biology of this tick have been made in India by Christophers (1907), in Jamaica by Newstead (1909), and in Texas by Hunter and Hooker (1907), and by Hooker (1908).

The egg (Table XXXII).—Christophers reports that engorged females after dropping from the host at once proceed to crawl away, climbing upward sometimes to a height of over 15 feet from the ground, into cracks and crevices. He states that it often crawls into cracks so narrow that it becomes firmly wedged in. We also have observed that there is a decided tendency for the females to crawl upward. It appears certain that the majority of females drop and deposit eggs in or near the kennel or sleeping place of the dogs.

Temperature has a very marked influence on the preoviposition period. In July and August at a mean temperature of about 85° F., oviposition began on the third day after dropping, while ticks which dropped on November 1, 2, and 3, did not begin to oviposit until the fifty-fourth, sixty-ninth, and eighty-third days, respectively, after dropping. The mean temperature during these periods was about 62° F.

The period of deposition is also decidedly affected by the temperature. This period varied from 8 to 67 days. The cool weather tends to produce intermittent deposition. The largest number of eggs recorded, 2,616, was deposited within a period of 11 days, beginning on September 5, by a tick which measured 10 by 7 by 4.5 mm. The large daily deposition and the short period required for oviposition during warm weather are noticeable characteristics of this species. Of the 12 cases in which oviposition was recorded the smallest number of eggs was 360. This was in November. The average of the 12 females was 1,601 eggs. Death usually takes place between the first and fourth days after deposition is complete.

The minimum incubation period recorded was 19 days. This record was made on eggs deposited on August 21 and kept at a mean temperature of 83.5° F. An effective temperature of 774° F. appears to be required for incubation. Christophers states that eggs hatch in 3 or 4 weeks.

TABLE XXXII.—*Incubation and larval longevity of Rhipicephalus sanguineus.*

IN THE LABORATORY.

Eggs deposited.	Hatching began.	Minimum incubation period.	All larvæ dead.	Larval longevity.	Temperature during incubation.			
					Maximum.	Minimum.	Average daily mean.	Total effective.
		Days.		*Days.*	*°F.*	*°F.*	*°F.*	*°F.*
Mar. 31, 1908	May 10, 1908	41			85.0	47.0	69.00	1,066.37
Apr. 18, 1908	May 26, 1908	39	July 7, 1908.	42	87.0	47.0	72.18	1,138.25
Apr. 20, 1908	May 27, 1908	38			87.0	47.0	72.33	1,082.25
Apr. 22, 1908	May 26, 1908	35			87.0	47.0	72.05	986.25
July 7, 1908	July 27, 1908	21	Oct. 7, 1908	72	95.0	74.0	83.99	860.50
July 29, 1908	Aug. 17, 1908	20	After Sept. 10, 1908	24+	99.0	73.0	86.50	870.00
July 31, 1908	Aug. 19, 1908	20	Sept. 30-Oct. 26, 1908	42–68	99.0	73.0	86.70	874.00
Aug. 2, 1908	Aug. 22, 1908	21	Sept. 28, 1908	37	99.0	73.0	86.26	908.50
Aug. 21, 1908	Sept. 8, 1908	19	Nov. 13-26, 1908.	66–79	97.5	75.0	83.73	774.00
Aug. 25, 1908	Sept. 12, 1908	19	do	62–75	97.5	74.5	83.90	777.20
Aug. 26, 1908	Sept. 14, 1908	20	do	60–73	97.5	74.5	83.60	812.45
Oct. 21, 1908	Mar. 11, 1909	142	After Apr. 24, 1909	44+	85.0	17.0	60.88	2,314.00
Sept. 20, 1910	Nov. 12?, 1910	54 (about).	Feb. 20, 1911	100 (about)				
OUT OF DOORS.								
Apr. 13-26, 1906	May 27, 1906	45	Aug. 15, 1906	80	93.0	41.5	69.08	1,173.60
Apr. 28, 1906	May 30, 1906	33			93.0	42.0	71.72	947.76
Before May 4, 1906	June 5, 1906	33+						
May 17, 1906	June 9, 1906	24			93.8	59.2	76.90	813.60

The larva (Table XXXIII).—The longevity of larvæ in summer under the most favorable conditions was 80 days. Several lots are recorded, however, in which the longevity was much shorter, the average life being not far from 2 months. The last individuals of a lot of larvæ from eggs deposited from August 4 to 6, 1907, and which commenced to hatch August 25, died between January 3 and 10, 1908, thus having lived between 131 and 138 days. Christophers states that in nature the larvæ collect near the bottom of walls and wait for a dog to brush against the spot.

Engorgement took place in as soon as 3 days; the greatest number dropped from the third to the fifth days, and all dropped before the seventh day. Christophers found larvæ which he placed upon a dog to engorge and drop in from 3 to 4 days.

TABLE XXXIII.—*Engorgement of larvæ of Rhipicephalus sanguineus.*

Date larvæ applied.	Host.	Larvæ dropped engorged—days following application.									Total number dropped.
		1	2	3	4	5	6	7	8	9	
Oct. 3, 1907	Bovine	0	0	51	138	6	2	0	0	0	197
May 27, 1908	....do	0	0	0	58	18	2	0	0	0	78
June 5, 1908	....do	0	0	25	85	31	0	0	0	0	141

At a mean temperature of 82° F. larvæ which dropped engorged on June 18, 1908, commenced to molt on the sixth day, while ticks which dropped October 6–8 did not commence to molt until the twentieth and twenty-third days. An effective temperature of 235° F. was required. Christophers states that 9 or 10 days are required for molting.

The nymph (Tables XXXIV, XXXV).—In order to determine the longevity of nymphs, a large number which molted September 30 and 31, 1907, were kept in a tube in the laboratory on moist sand. On March 5, 1908, 12 were alive, while on March 28 only one survived. On April 1 the remaining tick was found to be dead. Thus all of this lot were dead in 6 months from molting. Four of 6 nymphs which molted June 8 and 9, 1908, were dead August 3; on August 10 one was still alive, but on August 20 the last one was dead. Thus in summer nymphs lived but two and one-half months at the longest. Of a lot of 23 nymphs, slightly to one-third engorged, that were collected on dogs, October 29, 1910, 2 lived until April 5, 1911, or 158 days.

Engorgement was found to take place as soon as 4 days after attachment. The greatest number dropped on the fifth and sixth days; all were engorged and had left the host by the tenth day.

TABLE XXXIV.—*Engorgement of nymphs of Rhipicephalus sanguineus.*

Date nymphs applied.	Host.	Nymphs dropped engorged—days following application.										Total number dropped.
		1	2	3	4	5	6	7	8	9	10	
Nov. 7, 1907	Bovine	0	0	0	3	10	2	0	1	0	0	16
July 13, 1908	...do	0	0	0	3	10	15	5	5	1	0	39

In summer, when the mean temperature was between 84.65° F. and 85.42° F., molting has been observed to take place as soon as the twelfth day. A total effective temperature of 500° F. is required to produce this molt. The molting period of nymphs which form males appears to be the same as for those which form females. Christophers found 15 days to be required for molting.

TABLE XXXV.—*Molting of engorged nymphs of Rhipicephalus sanguineus.*

[♂=Male. ♀=Female.]

Date engorged nymphs dropped.	Host.	Number.	Engorged nymphs molted—days following dropping.														
			12	13	14	15	16	17	18	19	20	23	26	27	29	53	56
Sept. 22, 1907	Dog	1			1♀												
Oct. 27, 1907	...do	1										1♀					
Nov. 11, 1907	Bovine	3															
Nov. 12, 1907	...do	6														2♀	1♂
Apr. 22, 1908 [1]	Dog	11											6	4	1		
July 17, 1908	Bovine	3	1♂	1♂			1♀										
July 18, 1908	...do	10		3♂ 2♀	3♂ 2♀												
July 19, 1908	...do	15	2♀	5♂ 4♀	1♂ 2♀												
July 20, 1908	...do	5	1♀	1♂			2♂										
July 21, 1908	...do	3	1♀	1♀													
Aug. 17, 1908 [2]	Dog	100			7♂ 19♀	8♂ 14♀	9♂ 4♀	3♂ 2♀	1♀								
Aug. 18, 1908 [3]	...do	100		3♂ 7♀	2♂ 5♀	6♂ 9♀	4♀	3♂ 4♀	4♂ 3♀	1♂ 1♀	1♂						
Nov. 29, 1909	...do	64															
	Total	322															

Date engorged nymphs dropped.	Host.	Number.	Engorged nymphs molted—days following dropping.								Number molted.			Temperature from dropping to date first tick molted.		
			57	58	59	73	122	125	127	129	Male.	Female.	Total.	Maximum.	Minimum.	Average daily mean.
														°F.	°F.	°F.
Sept. 22, 1907	Dog	1										1	1			
Oct. 27, 1907	...do	1										1	1			
Nov. 11, 1907	Bovine	3	1♂	1♀							1	1	2			
Nov. 12, 1907	...do	6	1♀		1♀	1♀					2	4	6			
Apr. 22, 1908 [1]	Dog	11											11	86.0	47.0	70.39
July 17, 1908	Bovine	3									2	1	3	95.0	76.5	84.65
July 18, 1908	...do	10									6	4	10	95.0	76.5	84.70
July 19, 1908	...do	15									6	8	14	95.0	76.5	84.69
July 20, 1908	...do	5									3	1	4	95.0	76.5	84.92
July 21, 1908	...do	3									0	2	2	95.0	77.0	85.42
Aug. 17, 1908 [2]	Dog	100									27	40	67	96.0	75.5	83.90
Aug. 18, 1908 [3]	...do	100									20	33	53	93.0	75.5	83.55
Nov. 29, 1909	...do	64					10	3	2	2			17	92.0	20.0	55.97
	Total	322									67	96	191			

[1] Collected at Brownsville, Tex.

[2] Collected at Brownsville, Tex.; 27 of these nymphs were parasitized.

[3] Collected at Corpus Christi, Tex.; 40 of these nymphs were parasitized.

The adult (Table XXXVI).—Of 163 adults which were observed to molt from nymphs, 96, or 58.9 per cent, were females. The greatest adult longevity observed by us was between 204 and 214 days. This record was made on a lot of 13 males and 15 females which molted from nymphs September 1, 1908, and were kept in a tube on moist sand in the laboratory. On March 24, 1909, or after 204 days, a male and a female were alive. These were both dead on April 3, 1909. Other specimens which became adult in early September were found to live nearly as long as the lot above referred to. Several lots of ticks which became adult late in July and early in August lived from 77 to 158 days. One lot of ticks which became mature on May 18 to 21, 1908, lived about 3 months. Of a lot of 91 individuals collected on hosts on July 21, 1909, 4 were still alive December 15, 1909, having lived at least 147 days. However, a large percentage of the adults collected from dogs in the summer die within a month or 6 weeks. The longevity of the sexes appears to be about the same. We have observed unengorged adults crawling from between the cracks in floors. At Corpus Christi, Tex., they were found in considerable numbers in the cracks of a porch floor where dogs frequently slept. Christophers reports that after molting adults crawl into straw or similar material and there await the host.

Mating, which takes place on the host, may commence as soon as the fourth day after attachment and often continues until the engorged female drops. The male sometimes drops with the female or detaches soon after and goes in search of another mate. In one instance a male and partially engorged female in a tube on sand were observed apparently in copulation.

On November 19, 1909, Mr. J. D. Mitchell collected a male *Amblyomma americanum* in coitu with a female of this species on a dog at Corpus Christi, Tex. The mouth parts of the male were again inserted in the genital opening of the female when the ticks were put in a vial and they remained in this relation for at least fifteen minutes, when they were packed for mailing. Subsequently the female, which was partially engorged, deposited fertile eggs.

Fertilized females were found to engorge more rapidly than unfertilized ones. In one instance a female engorged in 6 days, while in several instances females remained attached for from 44 to 50 days, and even then were not fully engorged when they dropped. It is quite apparent that fertilization is an important factor in the period required for engorgement, as in the short period mentioned above the ticks mated on the fourth day after attachment, while in the extremely long periods mentioned mating did not occur at all.

TABLE XXXVI.—*Engorgement of females of Rhipicephalus sanguineus.*

Adults applied.	Host.	Females dropped engorged.	Period of attachment. *Days.*	Size engorged.
Oct. 26, 1907	Dog	Nov. 2, 1907	7	9.5 by 6.5 by 4 mm.
Do.	do	Nov. 3, 1907	8	11 by 7 by 4 mm.
Jan. 4, 1908	Bovine	Feb. 17, 1908	44	
Do	do	Feb. 18, 1908	45	8 by 5 by 3 mm.
Do	do	Feb. 23, 1908	50	
Apr. 4, 1908	do	Apr. 10, 1908	6	9 by 6 by 3 mm.
Do	do	Apr. 11, 1908	7	8 by 5 by 2 mm.
Do	do	Apr. 12, 1908	8	6 by 4 by 1.5 mm.
Do	do	do	8	8 by 5 by 2 mm.

Males do not appear to remain attached to the host after the females have dropped. If they do not drop with the females they start out in search of another mate; in this search they frequently go from one dog to another. Their longevity on the host is at least several months.

LIFE CYCLE.

Oviposition may commence as soon as the third day, and as many as 2,616 eggs may be deposited. In August eggs may hatch in 19 days, an accumulated effective temperature of 774° F. appearing to be required for their incubation. Larvæ may live for 131 to 138 days while waiting for a host; they may engorge in 3 days and molt in 6 days. A total effective temperature of 235° F. is required to produce this molt. During the winter nymphs may live for 6 months; they may engorge in 4 days after attaching to a host. In summer they may molt in 12 days, a total effective temperature of 500° F. being required. Adults may live as long as 204 days; they may become engorged in 6 days after attaching to an animal; fertilization takes place on the host. All stages of the tick may be found at any time during the year. However, they are less numerous after long continued drought.

ECONOMIC IMPORTANCE.

This species is perhaps the most important tick that attacks the dog. While restricted in its distribution to the Tropical and Subtropical life zones, it is widely distributed over the Old and New Worlds, in both of which it is the source of great annoyance to dogs. Its particular importance, however, lies in the fact that it is the active agent in the transmission of canine piroplasmosis. Fortunately this disease has not been introduced into the New World. It is, however, prevalent in certain sections of the Old World, particularly in India. The disease also occurs in South Africa, where it has been shown by Lounsbury to be transmitted by *Hæmaphysalis leachi.*

NATURAL CONTROL.

While no particular investigation has been made of the predaceous enemies of the species, those attacking the cattle tick undoubtedly destroy this tick also.

In 1908 a parasite was discovered which destroys large numbers of this species while in the nymphal stage. This parasite, the second recorded as attacking ticks, was described by Dr. L. O. Howard (1908) as *Hunterellus hookeri.* In order to determine the percentage of parasitism, 100 engorged nymphs were collected at Brownsville, Tex., August 17, 1908, and an equal number from Corpus Christi on August 18, 1908. These were isolated in pill boxes in lots of 10 each and kept on moist sand. Of the 100 collected at Brownsville, 27 were parasitized, 67 produced adult ticks (27 males and 40 females), and 6 did not produce either ticks or parasites. Of the 100 collected at Corpus Christi, 40 were parasitized, 53 produced adult ticks (20 males and 33 females), and 7 produced neither ticks nor parasites. Although a number of lots of nymphs have been collected which have shown no signs of parasitism, the insect is undoubtedly an important enemy of this tick. The parasite appears to be more restricted in its distribution in the United States than is the tick. Recently Mr. C. W. Howard has reared this parasite in Portuguese East Africa from the same host.[1]

ARTIFICIAL CONTROL.

Spraying frequently with, or dipping in a solution of one of the several coal-tar products that are now on the market should be practiced when this tick becomes a pest. It is important that the kennels or other sleeping places of dogs be kept scrupulously free from filth and that they be thoroughly sprayed at frequent intervals with some strong disinfectant. The destruction of roving and uncared-for dogs also greatly aids in the control of this tick.

Genus MARGAROPUS Karsch.

Of all the ticks those belonging to the genus Margaropus are the most important economically, owing to the part which they play in the transmission of Piroplasma and Anaplasma, which cause splenetic fever in bovines. Neumann recognizes 5 varieties of *annulatus*, all of which appear to transmit piroplasmosis. In addition to *annulatus*, we have studied the variety *australis*. One variety, *decoloratus*, is known to transmit *Spirochæta theileri*, which is the cause of a disease of cattle in South Africa. All of the ticks of this genus pass both molts upon the host.

THE NORTH AMERICAN CATTLE TICK.[2]

Margaropus annulatus (Say).

The common name of this species comes from the fact that it is the most common and important tick attacking cattle in North America.

DESCRIPTIVE.

Adult (Plate VIII, figs. 1, 6–11).—Males from 2 by 1.25 mm. to 2.4 by 1.3 mm. Females, unengorged, about 3 by 1.75 mm.; engorged, from 10.5 by 6 by 4.5 mm. to 14 by 9 by 6 mm.

Nymph (Plate VIII, figs. 3–5).—Unengorged, about 1.5 by 0.6 mm.; engorged, about 3 by 2.8 by 0.8 mm. Color, unengorged, light yellowish or grayish brown; capitulum and shield light reddish brown; legs pale yellowish brown; engorged, grayish blue. Capitulum 0.296 mm. long (from tip of palpi to base of emargination of scutum); scutum 0.478 mm. long by 0.455 mm. wide.

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[1] More recent studies of this parasite have been published by Wood (1911).

[2] The data on the cattle tick are presented in order that its biology may be compared with that of the other ticks. For more detailed information see Bulletin 72 of this bureau. The discovery of the fact that *Dermacentor venustus* conveys the infection of Rocky Mountain spotted fever has made it desirable that the above name be applied in place of that of North American fever tick, used in Bulletin 72.

Larva (Plate VIII, fig. 2).—Unengorged, about 0.547 by 0.413 mm.; engorged, 1.5 by 0.75 mm. Color unengorged, capitulum and scutum dark reddish, legs a shade lighter, body almost colorless; engorged, light yellowish gray. Capitulum 0.148 mm. (from tip of palpi to base of emargination of scutum); scutum 0.296 mm. long by 0.341 mm. wide.

Egg.—Ellipsoidal, deep yellowish brown, shining, smooth. The average size of 10 specimens measured was 0.542 by 0.418 mm.

HOST RELATIONSHIP.

The type host is the Virginia white-tailed deer, *Cervus virginianus* Boddoert [=*Odontocœlus americanus* (Erxleben)]. Of the undomesticated animals the deer is the only host known.

Bovines are the principal hosts of the species, but the tick also commonly attaches to horses and mules, and occasionally to sheep and goats. Only 4 engorged females have been taken by the writers from dogs, although numerous dogs have been examined and many attempts to induce this tick to attach to them have been made. Attachment to a human host very rarely takes place.

GEOGRAPHICAL DISTRIBUTION.

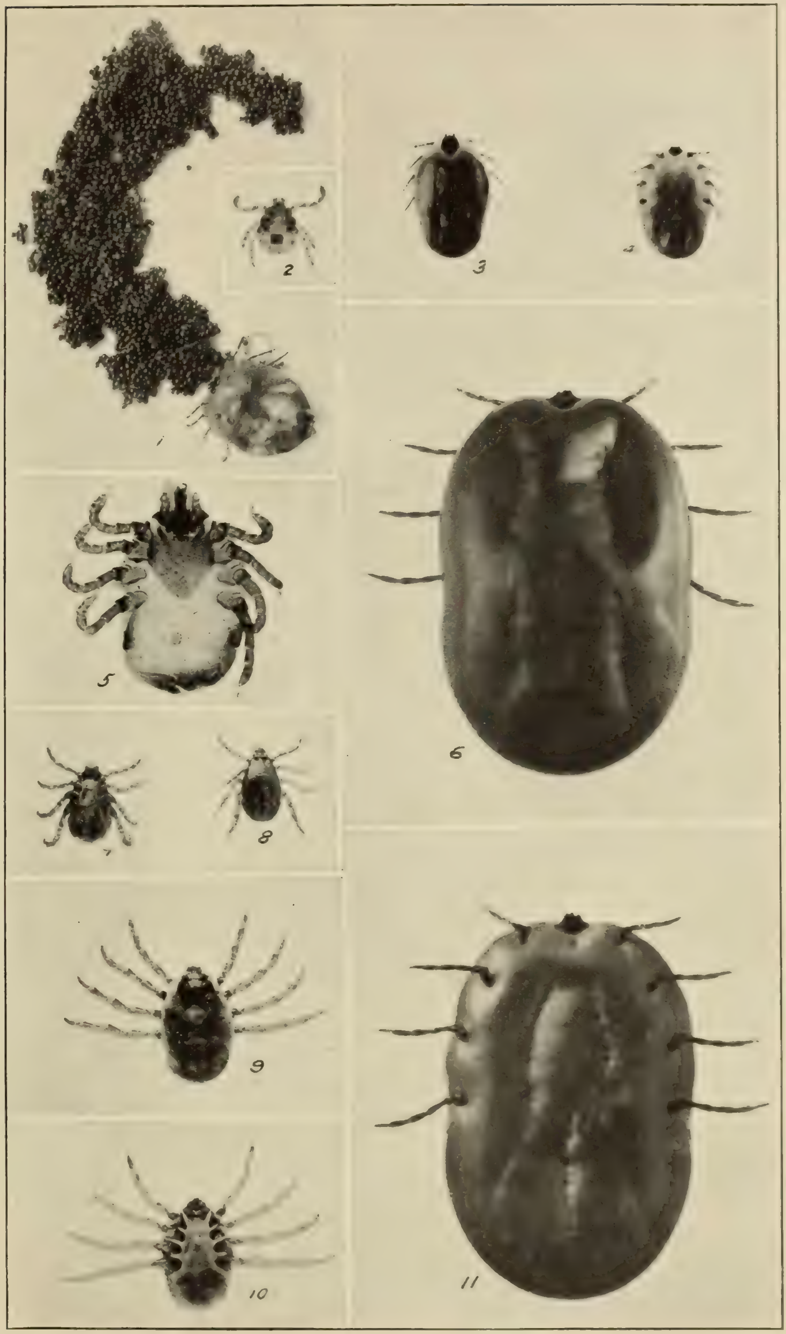
(Fig. 7.)

Florida is the type locality. This species is limited in distribution to the Lower Austral and a very small portion of the Upper Austral and Tropical Zones. The species occurs in greatest abundance in the humid or Austroriparian division of the Lower Austral Zone. It is known to occur only in the southern United States and Mexico, although it has been carried from this territory upon the host. The quarantine placed upon southern cattle by the United States Department of Agriculture now prevents its introduction into the Northern States.

LIFE HISTORY.

Owing to the economic importance of this species its life history and habits are better known than those of any other tick. Studies of its biology have been made by Curtice (1891), Morgan (1898), Newell and Dougherty (1906), Hunter and Hooker (1907), Cotton (1908), Graybill (1911), and others.

The egg (Tables XXXVII–XXXIX).—During the warmer months of the year oviposition commences on the second or third day after dropping. Occasionally eggs may be deposited on the day following dropping. During the winter months the preoviposition period is



THE NORTH AMERICAN CATTLE TICK, MARGAROPUS ANNULATUS.

Fig. 1.—"Deposited-out" female with eggs. Fig. 2.—Unengorged larva. Fig. 3.—Engorged nymph, dorsal view. Fig. 4.—Engorged nymph, ventral view. Fig. 5.—Unengorged nymph (balsam mount). Fig. 6.—Fully engorged female, dorsal view. Fig. 7.—Male, ventral view. Fig. 8.—Male, dorsal view. Fig. 9.—Unengorged female, dorsal view. Fig. 10.—Unengorged female, ventral view. Fig. 11.—Fully engorged female, ventral view. (Original.)

greatly lengthened. In one case a tick which dropped on November 20 did not begin depositing until January 25, giving a preoviposition period of 66 days. As a rule, however, the adults are killed by temperatures which are sufficiently low to retard deposition to this extent. The following table, which is based upon ticks which dropped from the host, shows an oviposition period of from 1 to 3 days and a deposition period of from 8 to 16 days. The average number of eggs deposited by the 10 ticks was 3,424 and the maximum number deposited by one female was 4,547.

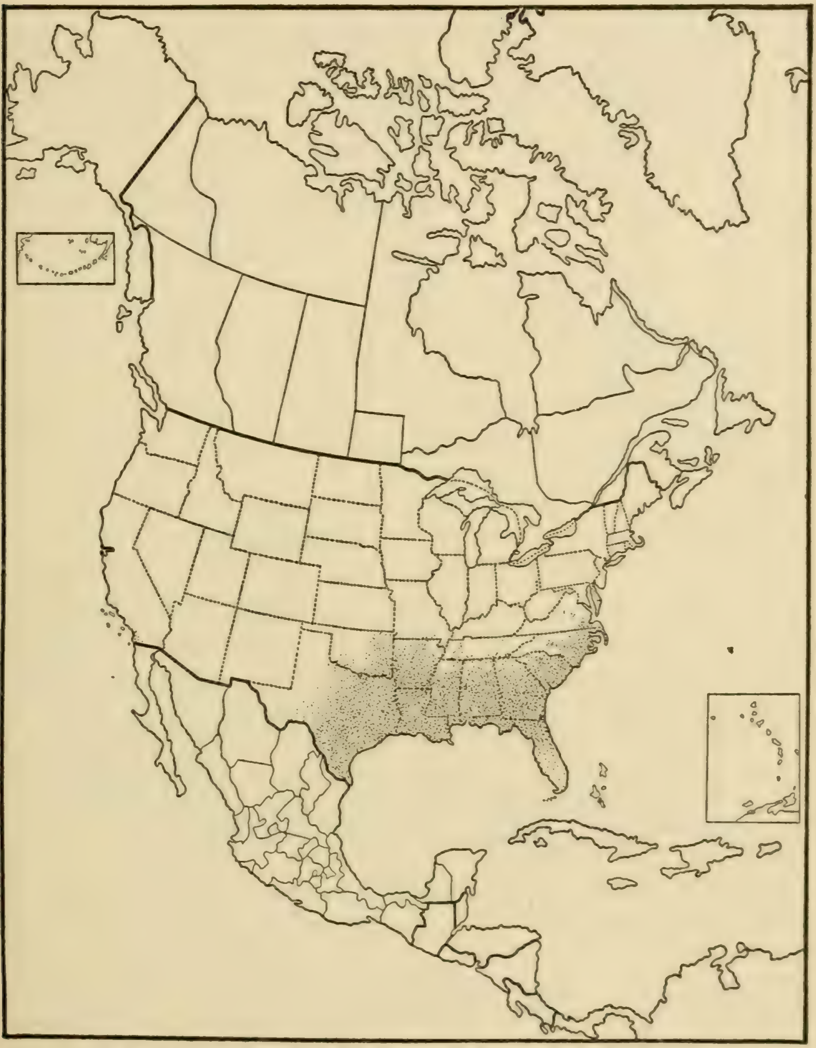


FIG. 7.—The North American cattle tick, *Margaropus annulatus:* Distribution in the United States. (Original.)

TABLE XXXVII.—*Oviposition of Margaropus annulatus engorged on bovine.*

Date engorged female dropped.	Size.	Number of eggs deposited—days following dropping.										
		1	2	3	4	5	6	7	8	9	10	11
1908.												
Aug. 3	12 by 7.5 by 6 mm	0	0	481	676	754	535	384	326	194	105	53
Aug. 4	14 by 9 by 6 mm	0	21	596	857	711	708	576	443	166	264	112
Do	13 by 7.5 by 5.5 mm	0	0	297	560	457	514	511	442	372	241	141
Do	12.5 by 7 by 5 mm	0	0	494	511	320	500	381	272	159	36	0
Aug. 6	12.5 by 8 by 5.5 mm	0	86	386	338	427	393	257	139	57	12	10
Do	13 by 8 by 5.5 mm	0	280	420	335	493	663	540	330	154	96	32
Aug. 7	13.9 by 5 by 5 mm	35	314	431	425	771	658	576	272	222	76	43
Aug. 6	13 by 8 by 6 mm	0	0	402	481	612	356	272	580	228	128	17
Aug. 8	13.5 by 8.5 by 6 mm	0	177	441	602	729	978	491	455	245	150	61
Do	12.5 by 8 by 5.5 mm	0	60	302	361	416	431	353	336	228	156	148

Date engorged female dropped.	Size.	Number of eggs deposited—days following dropping.										Total number of eggs.
		12	13	14	15	16	17	18	19	20	21	
1908.												
Aug. 3	12 by 7.5 by 6 mm	30	23	4	0	0	4	2	0	(1)	....	3,571
Aug. 4	14 by 9 by 6 mm	61	19	7	6	0	0	0	0	0	[2] 0	4,547
Do	13 by 7.5 by 5.5 mm	60	34	21	4	3	4	0	0	0	(1)	3,661
Do	12.5 by 7 by 5 mm	[3] 0	....	....	....	....	....	....	....	....	....	2,673
Aug. 6	12.5 by 8 by 5.5 mm	5	2	15	0	0	[4] 0	....	....	....	....	2,127
Do	13 by 8 by 5.5 mm	12	11	8	0	(1)	....	....	....	....	....	3,374
Aug. 7	13.9 by 5 by 5 mm	24	5	(1)	....	....	....	....	....	....	....	3,852
Aug. 6	13 by 8 by 6 mm	32	5	0	0	0	0	0	0	(1)	....	3,113
Aug. 8	13.5 by 8.5 by 6 mm	41	19	9	3	0	(1)	....	....	....	....	4,401
Do	12.5 by 8 by 5.5 mm	60	33	8	19	5	7	0	0	0	[5] 0	2,923
Average	....	....	....	....	....	....	....	....	....	....	....	3,424

[1] Died.
[2] Died on 27th day.
[3] Not completely deposited; appears injured.
[4] Apparently injured; died on 25th day.
[5] Died on 23d day.

The shortest period which we have observed to be required for incubation was 19 days and the longest was 202 days. During the former period the mean temperature was 87° F., the maximum being 102.5° F. and the minimum 71° F. During the latter period the mean temperature was 54.26° F., while the maximum was 92.5° F. and the minimum 14° F. In the laboratory in August eggs hatched as soon as the twentieth day after deposition, an effective temperature of 820° F. being required for their incubation.

TABLE XXXVIII.—*Incubation of Margaropus annulatus in the laboratory.*

Eggs deposited.	Hatching began.	Minimum incubation period.	Temperature during incubation.			
			Maximum.	Minimum.	Average daily mean.	Total effective temperature.
1908.	1908.	*Days.*	*°F.*	*°F.*	*°F.*	*°F.*
May 22	June 19	29	91.5	68	79.76	1,065
June 26	July 18	24	94	70.5	82	897
July 15	Aug. 6	22	95	76.5	85.15	969.50
Aug. 7	Aug. 26	20	99	73	85.51	850.25
Aug. 9	Aug. 29	21	96.5	73	84.76	877
Aug. 11	Aug. 30	20	96.5	75	84.88	837.50
Aug. 13	Sept. 2	21	96	75	84.62	874
Aug. 16	Sept. 4	20	96	75	84.01	820.25

TABLE XXXIX.—*Preoviposition, incubation, and longevity of larvæ of Margaropus annulatus out of doors.*

Date females collected.	Oviposition began.	Preoviposition period.	Hatching began.	Minimum incubation period.	All larvæ dead.		Larval longevity.
					Date.	Period from dropping of female.	
		Days.		*Days.*		*Days.*	*Days.*
Aug. 6, 1906	Aug. 19, 1906	13	Sept. 10, 1906	23	Apr. 9, 1907	246	211
Mar. 20, 1907	Mar. 24, 1907	4	May 30, 1907	68	July 20, 1907	122	51
May 8, 1907	May 12, 1907	4	June 22, 1907	42	Aug. 27, 1907	111	66
July 3, 1907	July 6, 1907	3	July 27, 1907	23	Oct. 5, 1907	94	69
July 31, 1907	Aug. 3, 1907	3	Aug. 26, 1907	24	Dec. 10, 1907	132	106
Aug. 21, 1907	Aug. 25, 1907	4	Sept. 21, 1907	28	May 22, 1908	275	244
Sept. 25, 1907	Sept. 30, 1907	5	Mar. 27, 1908	180	June 30, 1908	279	95
Mar. 20, 1908	Mar. 29, 1908	9	May 22, 1908	55	Aug. 13, 1908	146	83
July 1, 1908	July 5, 1908	4	July 28, 1908	24	Nov. 8, 1908	130	103
July 21, 1908	July 25, 1908	4	Aug. 18, 1908	25	Mar. 31, 1909	253	225
Aug. 12, 1908	Aug. 14, 1908	2	Sept. 9, 1908	27	May 13, 1909	274	246
Sept. 16, 1908	Sept. 23, 1908	7	Dec. 15, 1908	84	May 4, 1909	230	140
Oct. 5, 1908	Oct. 17, 1908	12	Mar. 23, 1909	158	July 5, 1909	273	104
May 24, 1909	May 29, 1909	5	June 28, 1909	31	Aug. 15, 1909	83	48
Aug. 2, 1909	Aug. 5, 1909	3	Aug. 27, 1909	23	Sept. 25, 1909	54	29
Sept. 6, 1909	Sept. 10, 1909	4	Oct. 14, 1909	35	May 7, 1910	243	205
Sept. 27, 1909	Oct. 4, 1909	7	Mar. 4, 1910	152	June 12, 1910	258	100
Nov. 8, 1909	Nov. 20, 1909	12	May 24, 1910	186	July 21, 1910	255	58

The larva (Tables XXXIX, XL).—Larvæ have been found to live as long as 246 days during cool weather and during midsummer from a few days to 100 days. The longevity of the larvæ given in Table XXXIX is based upon the entire number of eggs deposited by a female, the period being figured from the day the hatching of the lot began until all larvæ in the lot were dead. All were kept in large tubes with cloth tops and soil bottoms. These were set in the ground beneath a thin burlap shelter; otherwise the conditions were normal.

Molting begins from the fifth to the twelfth day after application to a host and usually all larvæ molt to nymphs within 16 days after attachment.

The nymph (Table XL).—After the larval skin splits the nymph crawls out and reattaches close to the old point of attachment. The larval skin sometimes remains attached to the host for several days. Nymphs have been found to become engorged and molt to adults as soon as 5 days after the larval molt. The period from attachment to the beginning of molting varies from 13 to 18 days. The length of the molting period of nymphs which become males is frequently from 1 to 3 days shorter than for those which become females.

The adult (Table XL).—The number of males and females which transform from a given lot of nymphs is approximately the same. As has been stated, the males usually appear from 1 to 3 days before the females. Both sexes crawl from the nymphal skin after it has been ruptured and reattach in the immediate vicinity of the old skin, which frequently remains attached to the host for several days. Before starting in search of mates the males usually feed for a short time, during which the chitin hardens; they then find females, with which they mate, or they may attach beneath engorged nymphs and await their transformation.

Females have been found to engorge and begin dropping on the fourth day after molting. The longest period observed between the first nymphal molt and the dropping of the first female was 14 days. In a large number of infestations the minimum parasitic period (from the application of larvæ to the beginning of dropping of females) was 20 days. The maximum parasitic period was 59 days and the average was 32 days.

TABLE XL.—*Parasitic period of Margaropus annulatus on bovines.*

Larvæ applied.	First molt.		Second molt.		Adults dropped.			Period, adult stage.		Period, attachment to dropping.		
	Date.	Period after application.	Date.	Period after first molt.	First.	Last.	Total number.	Minimum.	Maximum.	Maximum.	Minimum.	Average.
1907.	1907.	*Days.*	1907.	*Days.*	1907.	1907.		*Days.*	*Days.*	*Days.*	*Days.*	*Days.*
Feb. 16	Feb. 23	7	Mar. 3	8	Mar. 12	Mar. 22	72	9	19	34	24	29
July 12	July 18	6	July 27	9	Aug. 1	Aug. 9	89	5	13	28	20	24
1910. Oct. 14	1910. Oct. 20	6	1910. Oct. 29	9	1910. Nov. 5	1910. Nov. 21	712	7	23	38	22	30
Dec. 27	1911. Jan. 8	12	1911. Jan. 14	6	1911. Jan. 23	1911. Feb. 8	760	9	25	43	27	35
1911. Mar. 15	Mar. 23	8	Apr. 1	9	Apr. 10	Apr. 23	212	9	22	39	26	32.5

LIFE CYCLE.

At Dallas, Tex., the larvæ hatching from the entire mass of eggs deposited by a female have been found to survive for a period of 246 days from the time hatching began. The larvæ begin molting from the fifth to the twelfth day after application to a host. The nymphs become engorged and begin molting from the thirteenth to the eighteenth day. Adults sometimes engorge and drop as soon as the fourth day after the nymphal molt. The minimum period from the attachment of the larvæ to the dropping of the first engorged female was 20 days and the maximum period was 59 days. Oviposition may commence on the day following dropping, but usually the preoviposition period is at least 3 days. In the summer, when the mean temperature was 87° F., hatching began on the nineteenth day after the beginning of deposition. An effective temperature of at least 820° F. is required for incubation. The period from the dropping of the engorged females to the death of the last larvæ, or the nonparasitic period, varies from 28 days in summer to 279 days in fall, winter, and spring. In the southern part of the United States all stages of this tick may be found on hosts at any time during the year.

ECONOMIC IMPORTANCE, NATURAL CONTROL, AND ARTIFICIAL CONTROL.

These subjects are treated in detail in Bulletin 72 of the Bureau of Entomology and in Farmers' Bulletin 378 of the United States Department of Agriculture.

THE AUSTRALIAN CATTLE TICK.

Margaropus annulatus australis (Fuller).

The common name, Australian cattle tick, is taken from the scientific name, the latter having been given because the type material was collected in Australia.

DESCRIPTIVE.

Adult.—Males 2.5 by 1.25 mm. Females, unengorged, about 2.5 by 1.25 mm.; engorged, 10 by 7.5 by 5 mm. to 12 by 8.5 by 6 mm. The coloration is very similar to that of *annulatus* proper.

Nymph.—Unengorged, about 1.25 by 0.75 mm.; engorged, about 3 by 2.75 mm. Color very similar to *M. annulatus.* Capitulum 0.35 mm. long (from tip of hypostome to base of emargination of scutum); scutum 0.48 mm. long by 0.436 mm. wide.

Larva.—Unengorged, about 0.46 by 0.36 mm.; engorged, about 1.4 by 0.9 mm. Color as in *M. annulatus* proper. Capitulum 0.152 mm. long (from tip of palpi to base of emargination of scutum); scutum 0.275 mm. long by 0.356 mm. wide.

Egg.—Ellipsoidal, dark brown, shining, smooth. The average size of 10 eggs measured was 0.531 by 0.406 mm.

HOST RELATIONSHIP.

The host relations of this variety are about the same as those of *annulatus* proper. Cattle are the principal hosts, but the horse, goat, sheep, dog, rabbit (*Lepus cuniculus domesticus*), and man (for the larvæ) are reported as hosts by Rohr (1909), who has studied this variety in Brazil. Lahille (1905) reports that in Argentina he has found this tick on horses as well as cattle and has taken it once from the hide of a marsh deer, *Blastocerus dichotomus* Illiger (*B. paludosus* Desmarest). Newstead (1909), who has studied the ticks of Jamaica, states that in several instances mature specimens of both sexes were found on the dog. He reports it to be a general belief in Jamaica that the larva of this variety will attack any vertebrate animal that comes its way, but fails to present instances. He further states that the larva is a great pest to man. The habit of the larva of attaching to man as reported by Newstead and by Rohr appears to be similar to that of *Margaropus annulatus decoloratus* and unlike *M. annulatus* proper, which as a larva never attaches to a human host. The hosts reported by Neumann are cattle, horse, sheep, dog, and deer. One of the authors (Bishopp) found this tick in great numbers on cattle at Tampico, Mex., but very few were taken on horses. Mr. G. N. Wolcott has collected it on both horses and cattle in the Province of Pinar del Rio, Cuba.

GEOGRAPHICAL DISTRIBUTION.

This variety, which Neumann considers as including *microplus*, has a wide distribution. It undoubtedly occurs in all of the countries of South America, having been reported from British Guiana, Brazil, Paraguay, Uruguay, Argentina, and Chile. It is known to occur as far north as Tampico, Mex., where it was found to be a bad pest. In Central America it has been reported from Guatemala, Costa Rica, and Panama. It appears to be widely distributed in the West Indies, having been reported from Cuba, Jamaica, Porto Rico, Antigua, Guadeloupe, Dominica, and Trinidad.

The variety was described from Australia, where it has quite a wide distribution. It has also been reported from the Malay Archipelago (from Borneo and Sumatra), and Lounsbury has found it, as well as another variety, *decoloratus*, to occur in Cape Colony. C. S. Banks (1904) has reported the finding of this tick upon cattle which had arrived in the Philippine Islands 26 days before. He suggests that the ticks may have attached after arriving at Manila, in which case it may occur throughout those islands. From what he says in regard to the occurrence of larvæ on and in buildings near Manila where cattle are kept, it seems quite probable that this tick occurs there.

LIFE HISTORY.

Observations on the biology of this variety have been made by Pound (1899) in Australia, Lounsbury (1905) in Cape Colony, Lignières (1900), and Lahille (1904) in Argentina, Rohr (1909) in Brazil, and Newstead (1909) in Jamaica.

The egg (Table XLI).—In one instance oviposition commenced on the day following dropping and in another on the second day. Females which dropped on April 30, 1908, and were placed out of doors in tubes on sand commenced oviposition in from 5 to 13 days. The period of deposition as observed in 5 ticks varied from 15 to 23 days. The largest number of eggs deposited by any one of 11 ticks observed was 4,459 in which instance oviposition commenced on September 4, the second day following dropping. This female, which measured 12 by 8 by 5.5 mm., was the second largest tick observed. The average number of eggs deposited, based upon the 11 ticks observed, was 3,424. Rohr reports 3,046 to have been the maximum number of eggs deposited by any tick observed by him, with 1,529 as the minimum and 2,471 as the average for some 18 ticks.

TABLE XLI.—*Incubation and larval longevity of Margaropus annulatus australis.*

IN THE LABORATORY.

Eggs deposited.	Hatching began.	Minimum incubation period.	All larvæ dead.	Larval longevity.	Temperature during incubation.			
					Maximum.	Minimum.	Average daily mean.	Total effective.
1908.	1908.	*Days.*		*Days.*	*°F.*	*°F.*	*°F.*	*°F.*
May 13	June 5	24			88.5	65.0	77.76	834.25
May 14	June 6	24			88.5	65.0	78.14	843.50
May 16	June 8	24			90.0	68.0	79.09	866.25
OUT OF DOORS.								
May 5	June 6	33	August 27	82	91.0	43.0	75.31	1,066.1
May 6	June 8	34	August 15	68	93.0	43.0	76.04	1,123.2
May 7	June 9	34	August 19	71	93.0	43.0	76.69	1,145.5
May 8	June 8	32	August 14	67	93.0	43.0	77.16	1,093.0
May 11	June 10	31	August 7	58	93.0	60.5	77.93	1,082.8
May 13	June 8	27	August 24	77	93.0	60.5	77.87	941.6

Three lots of eggs, deposited May 13, 14, and 16, respectively, which were kept in the laboratory at a mean temperature of 77.8° F., hatched in 24 days, a total effective temperature of 834° F. being required for their incubation. Eggs which were deposited by ticks in tubes out of doors from May 5 to May 13 commenced to hatch in from 27 to 34 days. Rohr states that at a mean temperature of 30° C. (86° F.) eggs hatched in 19 to 23 days and at 35° C. (95° F.) in from 15 to 18 days. In this case the total effective temperature would be lowered somewhat. Lahille reports an instance in which eggs hatched in 20 days but does not give temperature records. He states that in one instance eggs deposited on April 30 passed the cold months and hatched September 6, or 129 days later.

The larva (Tables XLI–XLIV).—Our observations on the longevity of the larvæ are based upon the progeny of 6 ticks which dropped from a host on April 30, 1908, and which were at once placed in tubes on sand out of doors. The eggs from these ticks, which commenced depositing from May 5 to 13, were left with the ticks and commenced to hatch from June 6 to 10. The larvæ in the several tubes were all found to have died between August 7 and 24, or a maximum period of 82 days from the date the larvæ commenced to hatch. Thus it appears that at Dallas the progeny of ticks which dropped April 30 were all dead on August 24, or in a period of 116 days after the females dropped.

The larval molt occurs as soon as the sixth day after attachment, the last observed to molt having done so on the ninth day. Pound states that the molt takes place on the seventh day, Lahille reports it to occur from the seventh to the ninth day, while Rohr found 7 or 8 days to be required.

TABLE XLII.—*Nonparasitic period of Margaropus annulatus australis.*

Female dropped engorged.	Oviposition began.	Preoviposition period.	Hatching began.	Minimum incubation period.	All larvæ dead.		Larval longevity.
					Date.	Period from dropping of female.	
1908.	1908.	*Days.*	1908.	*Days.*	1908.	*Days.*	*Days.*
Apr. 30	May 5	5	June 6	32	Aug. 27	119	82
Apr. 30	May 6	6	June 8	33	Aug. 15	107	68
Apr. 30	May 7	7	June 9	33	Aug. 19	111	71
Apr. 30	May 8	8	June 8	31	Aug. 14	106	67
Apr. 30	May 11	11	June 10	30	Aug. 7	99	58
Apr. 30	May 13	13	June 8	25	Aug. 24	116	77

The nymph (Tables XLIII–XLIV).—The nymphs were found to molt as soon as the eighth day, or 14 days after attachment, the last observed molting on the thirteenth day, or 19 days after attachment. It was observed that in molting, as in *annulatus* proper, the young nymphs detach from the old point of attachment and reattach about one-eighth of an inch away, the old skins remaining attached to the hide after being shed.

Pound reports 7 days to be required for the nymphal stage, while Lahille places this period at 9 days.

The adult (Tables XLIII–XLIV).—In molting the females, like the nymphs, move from the old points of attachment, leaving the skins, and attach from one-sixteenth to one-eighth of an inch away. The mating habits of *australis* are similar to those of *annulatus* proper. After molting the male feeds for a number of hours and then starts in search of a mate with which, when found, it may remain until the female drops engorged. Males have been observed to remain in the position of copulation with females of *Margaropus annulatus* and *Dermacentor nitens* as long as 3 days. Lahille has observed copulation to take place off the host. We have not determined the period that the males remain upon the host, but Lounsbury states that it is usually about a month.

The adults have engorged and dropped as soon as the twenty-second day after attachment or 8 days after molting. In three infestations observed, the last engorged female dropped on the twenty-seventh day from attachment, or 9 days after the last nymph was observed to molt. Lounsbury reports the parasitic period (from the application of larvæ to the dropping of the females) to be from 18 to 38 days, but usually 23 days.

TABLE XLIII.—*The parasitic period of Margaropus annulatus australis.*

INFESTATION No. 1.

Date.	Remarks.
1908.	
Apr. 6, 4 p. m.	Larvæ placed on bovine.
Apr. 7 (1st day)	All attached.
Apr. 12 (6th day)	Several larvæ molting.
Apr. 13 (7th day)	A large percentage molted.
Apr. 14 (8th day)	All larvæ molted.
Apr. 21 (15th day)	Four nymphs molted (3 males, 1 female).
Apr. 22 (16th day)	A total of 20 molted.
Apr. 23 (17th day)	A total of 40 molted; one not molted.
Apr. 24 (18th day)	All have molted.
Apr. 25 (19th day)	Several mated.
Apr. 27 (21st day)	One female fully engorged but still attached.
Apr. 28 (22d day)	One female dropped engorged.
Apr. 29 (23d day)	Two females dropped. Seven fully engorged still attached.
Apr. 30 (24th day)	Fourteen females dropped engorged.
May 1 (25th day)	Four females dropped engorged.
May 3 (27th day)	The last female dropped engorged.

INFESTATION No. 2.

Date.	Remarks.
Aug. 11, 11 a. m.	Larvæ (hatched July 11) placed on bovine.
Aug. 12 (1st day)	All attached.
Aug. 17 (6th day)	Several molting.
Aug. 18 (7th day)	All but two or three have molted.
Aug. 19 (8th day)	All have molted.
Aug. 25 (14th day)	Two nymphs molted to males.
Aug. 26 (15th day)	Three more have molted.
Aug. 28 (17th day)	All have molted.
Aug. 29 (18th day)	All mated.
Sept. 1 (21st day)	Several females fully engorged
Sept. 2 (22d day)	Six females dropped engorged.
Aug. 4 (24th day)	Five females, the last, dropped engorged.

INFESTATION No. 3.

Date.	Remarks.
Aug. 20, 6 p. m.	Larvæ (hatched July 11) placed on bovine.
Aug. 21 (1st day)	All attached.
Aug. 26 (6th day)	Several molted.
Aug. 29 (9th day)	All have molted.
Sept. 5 (16th day)	Several nymphs molting.
Sept. 8 (19th day)	All the nymphs have molted.
Sept. 12 (23d day)	Four females fully engorged.
Sept. 13 (24th day)	Four females dropped engorged and several others are fully engorged.
Sept. 14 (25th day)	Eighteen fully engorged females were removed.
Sept. 17 (28th day)	One fully engorged female removed.
Sept. 18 (29th day)	One fully engorged female, the last, removed.

TABLE XLIV.—*Summary of parasitic periods of Margaropus annulatus australis.*

Infestation.	Larvæ.					Nymphs.				
	Attached.	First molted.		Last molted.		First molted.		Last molted.		Period following attachment.
		Date.	Period following attachment.	Date.	Period following attachment.	Date.	Parasitic period.	Date.	Parasitic period.	
	1908.	1908.	*Days.*	1908.	*Days.*	1908.	*Days.*	1908.	*Days.*	*Days.*
1	Apr. 6	Apr. 12	6	Apr. 14	8	Apr. 21	9	Apr. 24	12	15–18
2	Aug. 11	Aug. 17	6	Aug. 19	8	Aug. 25	8	Aug. 28	11	14–17
3	Aug. 20	Aug. 26	6	Aug. 29	9	Sept. 5	10	Sept. 8	13	16–19

TABLE XLIV.—*Summary of parasitic periods of Margaropus annulatus australis*—Continued.

Infestation.	Females dropped.				
	First.		Last.		Period following attachment.
	Date.	Parasitic period.	Date.	Parasitic period.	
	1908.	*Days.*	1908.	*Days.*	*Days.*
1	Apr. 28	7	May 3	12	22–27
2	Sept. 2	8	Sept. 4	10	22–24
3	Sept. 13	8	Sept. 18	13	24–29

LIFE CYCLE.

Under favorable conditions the progeny of a single tick may survive for a period of 82 days from the date hatching commences. The larvæ usually molt on the sixth day following attachment to the host, although in some instances as many as 9 days may be required. The nymphs usually molt in from 8 to 10 days later, but as many as 13 days have been observed to be required in some instances. Adults have been found to engorge in 7 days. In our observations the last females dropped engorged on the twenty-ninth day from attachment, but the period would probably be longer if males were not present. In one instance oviposition commenced on the day following dropping, but usually several days pass before such takes place. In June, at a mean temperature of 78° F., hatching began on the twenty-third day. An effective temperature of 834° F. appears to be required for incubation.

ECONOMIC IMPORTANCE.

This tick is so closely related to our species (*Margaropus annulatus*) that what has been said of *annulatus* proper regarding its importance as a pest may also apply to it. In the countries where it occurs *australis* is the same great pest that *annulatus* is in the southern United States, and transmits *Piroplasma bigeminum* in a similar manner. The habit of the larvæ in attaching to man, however, adds to its importance.

NATURAL CONTROL.

As with *annulatus*, birds (particularly blackbirds), mice, ants, toads, and lizards are probably its principal natural enemies. In Jamaica, the tinkling grackle (*Quiscalus crassirostris*), and the ani or "parrot-billed blackbird" (*Crotophaga ani*) are reported by Newstead (1909) to be its principal bird enemies.

ARTIFICIAL CONTROL.

The methods applicable in the control of *annulatus* proper apply in a general way to *australis.* Our observations indicate that the longevity of the larvæ may be somewhat shorter than that of *annulatus.* The long periods of warm weather in the Tropics should greatly assist in its eradication through starvation. If, however, the larvæ attach to small animals, as has been reported by Newstead (1909), and these develop to adults in any numbers, its eradication will be much more difficult.

Genus **AMBLYOMMA** Koch.

The five species of the genus Amblyomma which occur in the United States, namely, *americanum, cajennense, dissimile, maculatum,* and *tuberculatum,* have been studied and are considered in the following pages. The other species of this genus whose biology has been studied are *variegatum* by Barber (1894–95), in Antigua, *goldii* and *varium* by Rohr (1909), in Brazil, and *hebræum* (1899), *marmoreum,* and *variegatum* (1905), by Lounsbury, in South Africa. All five species which occur in this country and the three species studied in South Africa drop to pass the two molts. This also appears to be the case with the Brazilian species studied. Aside from the species which as adults attach to cold-blooded hosts only (*dissimile, goldii, marmoreum, tuberculatum*), the host relationship is not closely restricted. The species are able to withstand long periods of fasting while waiting for a host. While *americanum* is widely distributed, occurring in the Boreal and Austral regions, the other four species have only been found in the Tropical and Lower Austral Zones, three of these occurring only in the Gulf strip of the Austral Zone. The species are very hardy, yet require some protection, such as timber or underbrush; *maculatum,* however, exists on the prairie.

Only one species is known to transmit disease, namely, *hebræum,* which conveys the infection of heartwater of sheep, goats, and cattle in South Africa. Experiments to determine the possibility of *americanum* acting as a transmitter of splenetic fever of cattle have been conducted by two investigators. In both cases the results were negative.

THE GOPHER-TORTOISE TICK.

Amblyomma tuberculatum Marx.

The common name of the species is taken from the host of the adult.

DESCRIPTIVE.

Adult (Pl. IX, figs. 4–8).—Males from 7 by 4.5 mm. to 8 by 5 mm. Females, unengorged, 7 by 5 mm. to 10 by 6 mm.; engorged, 19 by 13.5 by 8 mm. to 24 by 18.5 by 11 mm. Males, scutum reddish brown, with a somewhat complicated pattern, formed by rather broad metallic bands. Female reddish brown, scutum with a large silvery mark on each side, containing one or two dark spots, and two divaricate, silvery stripes extending forward from the hind margin and sometimes connected with the lateral spots.

Nymph (Pl. IX, figs. 2, 3).—Unengorged, 2.25 by 1.5 mm. to 4 by 2.5 mm.; engorged, 7 by 5 by 2.5 mm. to 10 by 6.5 by 4 mm.; capitulum 0.932 mm. long (from tip of palpi to base of emargination of scutum); scutum 1.2 mm. long by 1.6 mm. wide. Unengorged nymphs are reddish brown; the scutum has a large silvery spot on each side, united behind at the tips and in front much broken by the large punctures. Engorged nymphs are dark gray in color.

Larva (Pl. IX, fig. 1).—Unengorged, about 1.03 by 0.76 mm.; engorged, about 4 by 3 by 1.5 mm. The color unengorged is brownish yellow, intestines showing through darker; lateral margins of the scutum of a pinkish color. The color of the engorged larvæ varies considerably; partially engorged specimens are usually dull gray and those which are fully engorged or nearly so usually have a purple color. Larvæ that have been fully engorged for some time have a bluish brown color.

Egg.—Ellipsoidal, reddish brown, shining, smooth. Maximum for 10 eggs measured 0.893 by 0.647 mm.; minimum 0.847 by 0.647 mm.; average 0.864 by 0.655 mm.

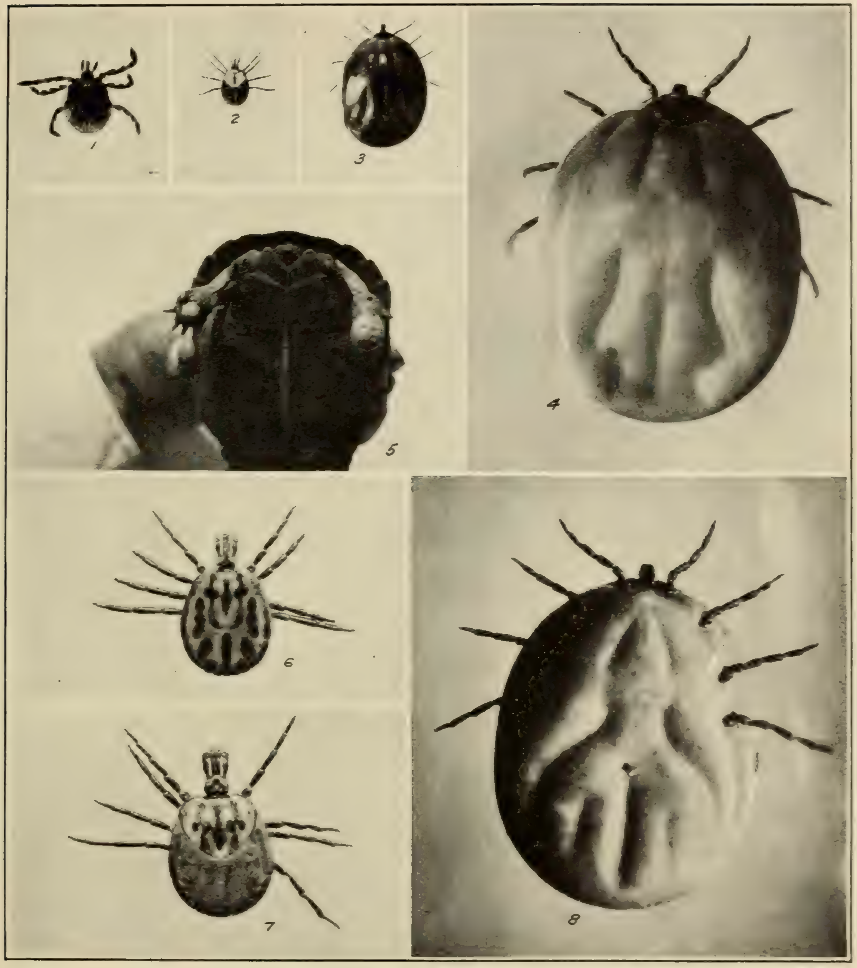
HOST RELATIONSHIP.

The adults of this tick have been collected from the gopher tortoise only. Experimental attempts to attach them to bovines have failed. The nymphs are commonly found on the gopher tortoise and have been engorged in experiments upon a bovine. Engorged larvæ have been collected in large numbers from dogs and rabbits and in smaller numbers from cattle and two birds of prey, namely, the owl and the hawk. The fact that the bird hosts discovered have been birds of prey has suggested the thought that the larvæ crawled to the bird host from the small mammals devoured by them.

GEOGPAPHICAL DISTRIBUTION.

(Fig. 8.)

The type locality of this tick is Crescent City, Fla. The species appears to be commonly met with on the peninsula of Florida as far north as Hawthorn and it is reported as being rather common in southern Alabama. Neumann (1899) reports that there is a male in the Paris Museum which was collected in Cuba.



THE GOPHER-TORTOISE TICK, AMBLYOMMA TUBERCULATUM.

Fig. 1.—Unengorged larva. Fig. 2.—Unengorged nymph. Fig. 3.—Engorged nymph. Fig. 4.—Engorged female, dorsal view. Fig. 5.—Females engorging on tortoise's feet. Fig. 6.—Male, dorsal view. Fig. 7.—Unengorged female, dorsal view. Fig. 8.—Engorged female, ventral view. (Original.)

LIFE HISTORY.

Observations on the biology of this tick have been published by Hooker (1909a).

The egg (Table XLV).—Three females were engorged upon a box tortoise. Their respective dimensions were: 24 by 18.5 by 11 mm.; 19 by 13.5 by 10 mm. and 19 by 13.5 by 8 mm. The first female weighed 2.35 grams. This and the last female had a preoviposition period of 8 days at a mean temperature of 84° F. The second female began depositing on the tenth day after dropping.

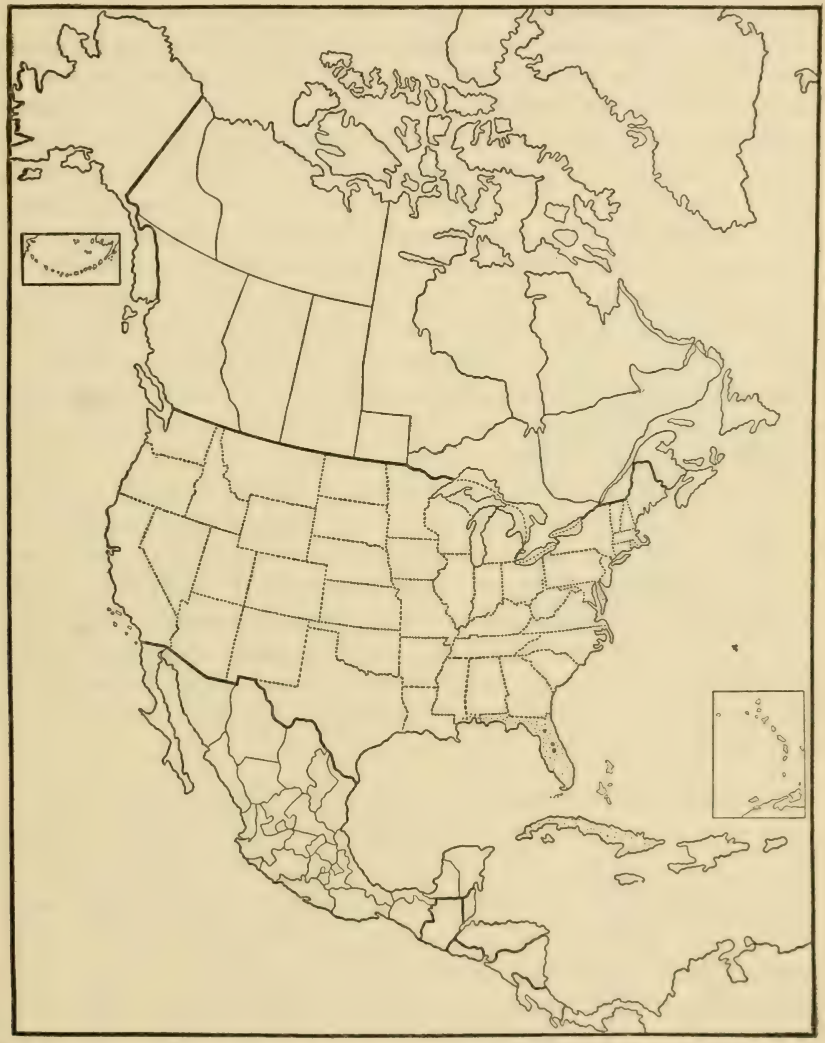


FIG. 8.—The gopher-tortoise tick, *Amblyomma tuberculatum:* Distribution. The large dots show localities where the species has been collected in our investigation. The small dots indicate the probable range of the tick. (Original.)

The deposition period of the first and second females was 21 and 16 days respectively. The largest number of eggs deposited was 5,481; the average 3,839. Oviposition continued in one case for 21 days.

Many of the eggs deposited by these females were black and shriveled when deposited and ultimately only a very small percentage of them hatched. It is believed that in nature several thousand more eggs would be deposited, as the females observed by us were still of large size when deposition ceased. The first female recorded in the table died on the thirty-fourth day after dropping and the second female died on the twenty-eighth day. Although the engorged females are much larger than in *Amblyomma maculatum,* the number of eggs deposited is probably less, due to the much larger size of the eggs of *tuberculatum.* The process of oviposition is very similar to that of the South African species of Amblyomma as described and illustrated by Lewis (1892). The viscid membranes or papillæ are protruded from between the capitulum and the scutum to a far greater extent than in *Margaropus annulatus*, as observed by Cushman (see p. 73). This membrane is prolonged into two horns, or arms (see fig. 9), by means of which the fluid is directed to the eggs as deposited. At the writers' request, Mr. R. A. Cushman has made the accompanying drawing of this organ.

The incubation period appears to be longer than in the other species of Amblyomma observed, 91 days being the minimum period recorded. The average mean temperature during this period was 70.19° F. and the total effective temperature 2,474° F. Under natural conditions this period may be somewhat shorter. The records given in the accompanying table were all made upon eggs kept in the laboratory on moist sand. Only a very small percentage of those deposited hatched, many of them being shriveled and black when deposited.

TABLE XLV.—*Incubation and larval longevity of Amblyomma tuberculatum.*

Eggs deposited.	Hatching began.	Minimum incubation period.	All larvæ dead.	Larval longevity.	Temperature during incubation.			
					Maximum.	Minimum.	Average daily mean.	Total effective.
1908.	1908.	*Days.*		*Days.*	°*F.*	°*F.*	°*F.*	°*F.*
Aug. 27	Dec. 4	100	Dec. 22, 1908	18	97.5	34.0	70.26	2,726
Aug. 29	Nov. 27	91	Mar. 2–17, 1909	95–110	97.5	34.0	70.19	2,474
Aug. 31	Dec. 4	96	Dec. 22, 1908	18	97.5	34.0	69.63	2,557
Sept. 1	Dec. 4	95	Mar. 3–20, 1909	94–106	97.5	34.0	69.47	2,515
Sept. 7	Dec. 4–29	114–	Jan. 13, 1909	15+				

The larva (Table XLV).—The greatest larval longevity observed by us was between 95 and 110 days. None of the lots, the longevity of which is recorded in Table XLV, contained more than 200 specimens and the three lots which had a longevity of from 15 to 18 days each contained only one or two larvæ. Three slightly engorged larvæ collected from a rabbit on December 21, 1907, were placed upon a bovine on March 10; two were found attached the following day, while the third was found dead on March 12. While the two ticks remained attached for only a few days, the fact that they reattached shows the possession of considerable vitality. A few specimens of a lot of larvæ from one-fourth to three-fourths engorged when collected November 30, 1908, lived for three months.

Engorged larvæ taken from a rabbit on December 21, 1907, and kept in the laboratory at a mean temperature of 61.4° F., did not commence to molt until 86 days later, having required a total effective temperature of 1,583° F. Engorged larvæ collected in November began to molt in from 107 to 147 days.

On the dog no particular preference as to position of attachment was observed, but on the rabbit the larvæ were found in great patches near the base of the ears, a few being in and on the ears. Larvæ have been taken in abundance on dogs and rabbits and a few specimens on cattle and sparrowhawks.

The nymph (Tables XLVI, XLVII).—On June 8, 1909, one nymph was alive in a tube which contained 8 specimens that molted from larvæ between March 15 and March 30, 1909. This individual had lived between 70 and 80 days up to the time it was put on a host (June 8). One nymph which molted March 11, 1909, was alive and able to attach to a host when applied on May 31, 1909, a period of 81 days after molting. Other lots which molted in March, 1909, and were kept on sand died in from 27 to 56 days. It should be stated that all of these nymphs were collected as larvæ late in the fall of 1908 and did not molt until March. Probably specimens dropping during warm weather so that they would molt to nymphs in a short time would live for a much longer period.

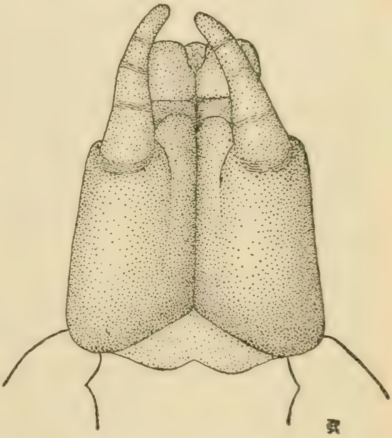


FIG. 9.—The gopher-tortoise tick: *Vesica biloba* extended between the scutum and capitulum in position to receive an egg from the ovipositor. Greatly enlarged. (Original.)

Nymphs were found to attach readily to a bovine, but some trouble was experienced on account of scabs forming around the mouthparts and causing the ticks to drop before becoming fully engorged. Specimens were found to change their point of attachment several times before imbibing much blood. The shortest period in which engorgement took place upon a bovine was 8 days, the greater number dropping on the ninth and tenth days, the last to leave the host dropping on the eleventh day. Upon a cold-blooded host the period of engorgement will undoubtedly be found to be much longer, as was found to be the case with *Ambylomma dissimile*. Attempts to get nymphs to attach to a horned toad were unsuccessful.

TABLE XLVI.—*Engorgement of nymphs of Amblyomma tuberculatum.*

Date nymphs applied.	Host.	Nymphs dropped engorged—days following application.											Total number dropped.
		1	2	3	4	5	6	7	8	9	10	11	
Apr. 14, 1908	Bovine	0	0	0	0	0	0	0	0	0	5	2	7
Apr. 15, 1908	do	0	0	0	0	0	0	0	1	2	3	2	8
May 20, 1908	do	0	0	0	0	0	0	0	1	4	3	2	10
May 7, 1909	do	0	0	0	0	0	0	0	1	0	0	0	1
May 11, 1909	do	0	0	0	0	0	0	0	0	0	1	2	3

At a mean temperature of 81° F. nymphs which dropped the last of May commenced to molt in 29 days, a total effective temperature of 1,104° F. having been required. The molting period of nymphs which become males and females is about the same. It was found that when the engorged nymphs were placed in tubes on moist sand they at once burrowed into it out of sight. When examined they were found an inch or more beneath the surface, in which position molting took place. This habit was not observed in engorged larvæ, but is probably the same. Although observations on this habit have not been made in other species of ticks, owing largely to the fact that it was necessary to keep them on an impenetrable surface in order that the exact dates of molting could be observed, it seems quite probable that some of them may do so also. Such a habit is of great advantage to the tick in protecting it from enemies during the quiescent period, as well as in preventing drying out.

TABLE XLVII.—*Molting of engorged nymphs of Amblyomma tuberculatum engorged on bovine.*

Date engorged nymphs dropped.	Number.	Engorged nymphs molted—days following dropping.															Number molted.			Temperature from dropping to date first tick molted.		
		29	32	36	37	38	39	44	46	48	49	51	53	66	203	207	Male.	Female.	Total.	Maximum.	Minimum.	Average daily mean.
																				°*F*	°*F*	°*F*
Apr. 23, 1908	1	0	0	0	0	0	0	0	0	0	0	0	0	1♂	0	0	1	0	1	91.5	47	76.29
Apr. 24, 1908	6	0	0	0	0	0	0	0	0	0	1♂ 3♀	... 1♀	1♂	0	0	0	2	4	6	89	47	74.72
Apr. 25, 1908	5	0	0	0	0	0	0	0	1♂	2♀	0	1♀	0	0	0	0	1	3	4	89	47	74.73
Apr. 26, 1908	2	0	0	0	0	0	0	0	0	0	1♀	0	0	0	0	0	0	1	1	91.5	47	75.11
May 28, 1908	1	0	0	0	1♂	0	0	0	0	0	0	0	0	0	0	0	1	0	1	91.5	69	80.50
May 29, 1908	4	0	0	1♀	0	1♂	1♀	1♀	0	0	0	0	0	0	0	0	1	3	4	91.5	69	80.61
May 30, 1908	3	1♂	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	91.5	69	81.05
May 31, 1908	2	0	0	1♂	1♀	0	0	0	0	0	0	0	0	0	0	0	1	1	2	91.5	69	81
Nov. 24, 1908	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1♀	0	1	1	100	17	67.15
Dec. 2, 1908	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1♂	0	1	0	1	100	17	67.89
May 21, 1909	1	1♀	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	100	47	86.17
May 22, 1909	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	...	...	1	100	47	86.56
Total	28	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	9	14	24			

The adult.—Among the individuals observed to molt to the adult stage there was a predominance of females. The greatest adult longevity observed was about 90 days; other specimens lived from 17 to 76 days. All of these records were made during midsummer. A few ticks of both sexes remained active, when kept in tubes in the laboratory, for more than 2 months during the summer before being placed upon a host. It is certain that with abundant material, placed under natural conditions, adults would be found to live much longer than those observed by us.

Several males and 3 females placed upon a tortoise on July 29, 1908, readily attached. The first female to engorge dropped 20 days later, measuring 24 by 18.5 by 11 mm. Next to *Amblyomma varium*, which has been recorded by Rohr (1909, p. 120) as measuring 28 by 24 by 15 mm., this is the largest tick on record. The second female dropped engorged on the twenty-first day after attachment and measured 19 by 13.5 by 10 mm. The third female dropped on the twenty-fifth day after attachment and measured 19 by 13.5 by 8 mm. During the period of attachment none of these females was observed in copulation. Upon removing the first female from the bag in which the tortoise had been placed it was found apparently in copulation with a male which had also dropped from the host. This fact suggests the possibility that copulation takes place after the female drops engorged.

Males have been observed to remain attached for a long time after the females drop, and this habit accounts for their being more commonly met with upon tortoises. One of the three males which attached to a tortoise July 29, 1908, remained on the host 43 days after the last female dropped and the other was still attached but dead when the tortoise died on January 5, 1909, thus having been attached 135 days after the last female dropped, or a total period of 160 days. The males attached to the margin of the shell as well as to the body of the tortoise. It is conceivable that the females may also thus attach to the shell, but if this actually occurs the period of engorgement must be greatly prolonged owing to the poor blood supply. Attempts to secure the attachment of adults to horned toads (*Phrynosoma cornutum*) were unsuccessful.

LIFE CYCLE.

Larvæ may live for at least 95 days during the winter months. The period required for engorgement has not been determined. At winter temperature in the laboratory at Dallas 86 days passed before molting commenced. During this period a total effective temperature of 1,583° F. was accumulated. The longest molting period recorded was 165 days. The greatest nymphal longevity recorded was 81 days. At the end of this period one specimen was still able to attach to the host. On a warm-blooded host the nymphs may engorge in 8 days and molting may commence as soon as 29 days after dropping. A total effective temperature of 1,104° F. appears to be required to produce this molt. Adults may live for 90 days and engorge as soon as 20 days after application to a host. Oviposition may commence as soon as the eighth day after dropping and as many as 5,481 eggs may be deposited. The minimum incubation period recorded (in winter) was 92 days. During this period a total effective temperature of 2,474° F. was accumulated.

ECONOMIC IMPORTANCE.

While this tick has not been considered of economic importance, the fact that it occurs on cattle and in large numbers on dogs and certain small mammals suggests the possibility of its becoming so.

NATURAL CONTROL.

No particular enemies of this tick have been observed. However, in experiments several ticks were lost by being devoured by the tortoise.

THE IGUANA TICK.

Amblyomma dissimile Koch.

The common name of this species is given it because the iguana was the first animal upon which we collected it as well as being one of its most common hosts. Newstead (1909, p. 445) has made use of the name "bullfrog tick."

DESCRIPTIVE.

Adult (Pl. X, figs. 3–5).—Males from 4 by 2.75 mm. to 5.25 by 3.33 mm. Females, unengorged, from 4 by 2.5 mm. to 5.5 by 3.75 mm.; engorged, from 14 by 9 by 5 mm. to 17 by 10 by 6 mm. Newstead has described the coloration of the engorged female as ochreous to yellowish gray; scutum chocolate brown with dull coppery markings, forming a distinct spot at the apex.

Nymph (Pl. X, fig. 2).—Unengorged, about 2 by 1.1 mm.; color varying from light to a darker brown. Length of capitulum 0.497 mm. (from tip of palpi to base of emargination of scutum); scutum 0.737 mm. long by 0.983 mm. wide. Engorged, from 4.5 by 3 by 2 mm. to 5 by 3.25 by 2 mm. The color varies according to whether blood or lymph has been engorged, the lymph giving a light gray, and the blood a brownish yellow color.

Larva (Pl. X, fig. 1).—Unengorged, from 0.867 by 0.578 mm. to 0.961 by 0.617 mm.; engorged, 2 by 1.15 mm. Capitulum 0.236 mm. long (from tip of palpi to base of emargination of scutum); scutum

0.9 mm. long by 0.6 mm. wide. The color varies as does that of the nymphs, a somewhat higher percentage of this species than others having a light gray color. A few have a pink color when they drop.

Egg.—Ellipsoidal, light brown, shining, smooth. The maximum size for 10 was 0.677 by 0.570 mm., the minimum 0.631 by 0.539 mm., with an average of 0.652 by 0.560 mm.

HOST RELATIONSHIP.

The type host is not known. This tick attaches to cold-blooded animals, particularly iguanas and toads, upon both of which it engorged at Dallas. The toad, however, died before the larvæ all engorged, due to being confined in a cage. In rearing experiments the larvæ and nymphs readily attached to and engorged upon a bovine, but the adults would attach to cold-blooded hosts only. It thus seems probable that in nature the immature stages attach to both cold and warm blooded animals and that the adults attach only to the former class. Newstead states that in Jamaica it is apparently confined to the common toad or so-called "bullfrog" of the island (*Bufo marinus*).

GEOGRAPHICAL DISTRIBUTION.

The type locality is Mexico. During 1907 nymphs and adults of this species were collected by one of the authors (Wood) from iguanas which had been brought to Brownsville, Tex., from the Isthmus of Tehuantepec. The species has been recorded from Mexico, Guatemala, Honduras, Nicaragua, Panama, Jamaica, Antigua, Barbados, Trinidad, Colombia, Venezuela, Guiana, Brazil, Paraguay, Argentina, and the Philippine Islands.

LIFE HISTORY.

The only information upon the biology of this tick that the authors have found is furnished by Newstead (1909). This author is in error in supposing that the molts are passed upon the host, as such is not the case.

Egg (Tables XLVIII, XLIX).—In the laboratory in June and July at a mean temperature of 82° to 86° F. oviposition commenced on the sixth day after dropping and continued for 16 and 17 days. The larger number of eggs deposited by the two females from which counts were made was 1,655. Newstead (1909, p. 446), however, records 1,784 from one female, deposition commencing on the seventh day and continuing for 17 days. The minimum incubation period recorded by us was 27 days. This record was made on eggs deposited early in August. The mean temperature during incubation was 85° F. An effective temperature of 1,133° F. appears to be required for the incubation of the eggs. The first tick, the oviposition of which is recorded in the following table, was about three-fourths engorged, having been collected on an iguana. The second female was engorged on a box turtle and measured 14 by 9 by 5 mm. It died on the twenty-fifth day after dropping.

TABLE XLVIII.—*Oviposition of Amblyomma dissimile.*

Date engorged female dropped.	Number of eggs deposited—days following dropping.																	Total number of eggs.
	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
June 2, 1908	235	342	208	275	134	158	70	25	21	36	26	16	10	5	0	10	2	1,573
July 30, 1908	186	318	317	283	132	142	95	64	38	32	18	7	12	5	2	4	0	1,655
Average																		1,614

TABLE XLIX.—*Incubation and larval longevity of Amblyomma dissimile.*

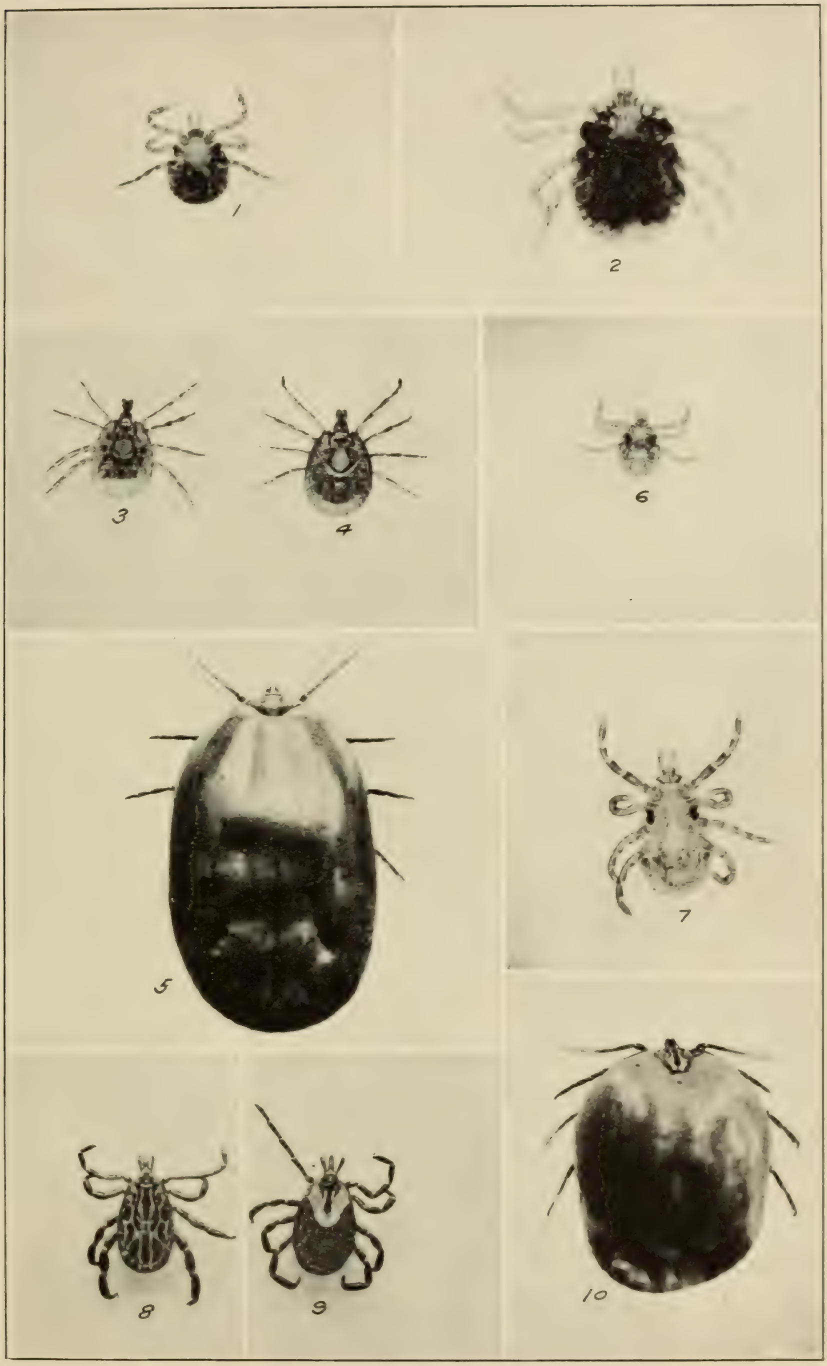
Eggs deposited.	Hatching began.	Minimum incubation period.	All larvæ dead.	Larval longevity.	Temperature during incubation.			
					Maximum.	Minimum.	Average daily mean.	Total effective.
1908		*Days.*	1908	*Days.*	*°F.*	*°F.*	*°F.*	*°F.*
May 5	June 13	40			91.5	56	76.93	1,357.5
May 18	June 21	35			91.5	68	80.57	1,283.5
June 9	July 14	36	Oct. 17	95	93.5	69	81.00	1,368
June 13, 14	July 15	33	Before Oct. 7	84	93.5	70.5	81.46	1,269
June 17	July 20	34	Oct. 2	74	90	70.5	82.01	1,326
Aug. 5, 6	Aug. 31	27	Nov. 13–26	74–87	99	73	85.17	1,138.5
Aug. 7, 8	Sept. 2	27	Nov. 13–26	72–85	99	73	84.96	1,133.
Aug. 8, 9	Sept. 5	29	Nov. 26–Dec. 9	82–95	96.5	73	84.53	1,204.5
Aug. 11–14	Sept. 7	28	Nov. 16	70	98.5	75	84.87	1,172

Larva (Tables XLIX–LI).—The longevity of larvæ which hatched on July 14, 1908, was 95 days. This was the greatest longevity observed by us. Engorgement took place on a bovine as soon as 4 days, the greatest number dropping from the fifth to seventh days. On a cold-blooded host (a tortoise) 10 days were required for engorgement. Ticks placed upon a bovine had all dropped on the ninth day, whereas upon a tortoise the last dropped upon the sixteenth day. An important point is here brought out in the fact that upon cold-blooded animals a much longer period is required for engorgement.

TABLE L.—*Engorgement of larvæ of Amblyomma dissimile.*

Date larvæ applied.	Host.	Larvae dropped engorged—days following application.												Total number dropped.
		4	5	6	7	8	9	10	11	12	14	15	16	
1908.														
July 2	Bovine	12	29	40	28	8	3	0	0	0	0	0	0	120
July 23	Tortoise	0	0	0	0	0	0	6	3	12	16	3	3	43
Aug. 11	Bovine	1	8	4	3	0	0	0	0	0	0	0	0	16

PLATE X.



THE IGUANA TICK, AMBLYOMMA DISSIMILE, AND THE GULF COAST TICK, AMBLYOMMA MACULATUM.

Amblyomma dissimile: Fig. 1.—Unengorged larva. Fig. 2.—Unengorged nymph (balsam mount). Fig. 3.—Male, dorsal view. Fig. 4.—Unengorged female, dorsal view. Fig. 5.—Fully engorged female (alive). *Amblyomma maculatum:* Fig. 6.—Unengorged larva. Fig. 7.—Unengorged nymph (balsam mount). Fig. 8.—Male, dorsal view. Fig. 9.—Unengorged female, dorsal view. Fig. 10.—Engorged female, dorsal view. (Original.)

At a mean temperature of 86.5° F. larvæ which engorged upon a tortoise molted as soon as the seventh day after dropping. However, the greatest number molted on the eleventh day. At a mean temperature of about 83.5° F. larvæ engorged upon bovines required a minimum of 10 days from dropping to molting, the greatest number molting on the twelfth day. Thus it appears that larvæ engorged on warm-blooded and cold-blooded animals have approximately the same molting period. A total effective temperature of at least 305° F. appears to be required for the molting of larvæ.

TABLE LI.—*Molting of engorged larvæ of Amblyomma dissimile.*

Date engorged larvæ dropped.	Host.	Number.	Engorged larvæ molted—days following dropping.									Total number molted.	Temperature from dropping to date first tick molted.		
			7	9	10	11	12	13	14	15	16		Max.	Min.	Av. daily Mean.
1908.													°F.	°F.	°F.
July 6	Bovine....	11	0	0	0	2	5	1	2	0	0	10	94	74	83.29
July 7	...do.......	24	0	0	1	5	13	2	1	0	0	22	94	74	83.45
July 8	...do.......	35	0	0	0	8	9	7	2	0	0	26	94	74	83.71
July 9	...do.......	23	0	0	0	0	0	2	0	0	0	2[1]	95	74	84.09
Aug. 2	Tortoise ..	6	0	0	0	4	2	0	0	0	0	6	99	73	86.37
Aug. 3	Toad......	8	0	0	0	0	0	7	0	0	0	7	99	73	86.51
Do....	Tortoise ..	3	0	0	0	3	0	0	0	0	0	3	99	73	86.41
Aug. 4	...do.......	12	0	2	5	3	1	0	0	0	0	11	99	73	86.14
Aug. 6	...do.......	17	1	0	2	12	2	0	0	0	0	17	99	73	86.59
Aug. 7	...do.......	2	0	0	0	1	1	0	0	0	0	2	99	73	86.94
Aug. 8	...do.......	3	0	0	1	2	0	0	0	0	0	3	96	73	86.30
Aug. 15	Bovine....	1	0	0	0	0	0	0	1	0	0	1[1]	96	75	84.32
Aug. 16	...do.......	8	0	0	0	0	0	0	1	1	0	2[1]	96	75.5	84.17
Aug. 17	...do.......	3	0	0	0	0	0	0	1	2	0	3	96	75.5	83.90
Aug. 18	...do.......	3	0	0	0	0	0	0	0	1	1	2[1]	93	75.5	83.61
	Total...	159	....	....	....	....	....	....	....	....	....	107[1]	....	....	....

[1] Some specimens in this lot were destroyed before they molted.

The nymph (Table LII).—In order to determine the longevity of nymphs, five lots, each containing several specimens, were kept in tubes on moist sand in the laboratory. The longevity of these lots varied from 86 to 130 days. Those which molted July 20, 1907, were all dead by October 26, 1907, or 95 days after molting. One among those which molted August 13–15, 1907, lived between 124 and 130 days; one of the lot which molted August 15–16, 1907, lived between 104 and 111 days, and one of those which molted August 29 to September 3, lived between 108 and 122 days.

The shortest period in which they engorged on a bovine was 5 days, the greatest number dropping on the sixth day. In August, 11 days were required for engorgement upon a tortoise, the greatest number requiring 13 days. It appears from these two tests that nymphal engorgement is much more rapid on warm-blooded than on cold-blooded animals.

TABLE LII.—*Engorgement of nymphs of Amblyomma dissimile.*

Date nymphs applied.	Host.	Nymphs dropped engorged—days following application.									Total number dropped.
		5	6	7	8	9	11	12	13	14	
1908.											
Aug. 1	Bovine....	1	6	1	2	0	0	0	0	0	10
Aug. 8	Tortoise...	0	0	0	0	0	1	1	4	2	8

The molting of 28 individuals was observed. In August, at a mean temperature of 83° F., molting commenced in 12 days, the greatest number molting from the fifteenth to seventeenth days. An effective temperature of at least 479° F. appears to be required. There is no marked difference in the periods required for the molting of nymphs engorged on warm-blooded and on cold-blooded hosts.

The adults.—Seventy-one per cent of the 28 individuals which molted to adults were females. On June 2, 1908, 4 males and 5 females which were slightly engorged were collected on an iguana. The last female of this lot died between July 18 and August, 1908, while one of the males lived until October 9, 1908, a period of 129 days. In a lot consisting of 1 male and 2 females which molted September 5, 1908, the male showed the greatest longevity, living 103 days, although it was very weak for over a month prior to its death. A female which molted September 13, 1908, lived about three months in a pill box under very unfavorable conditions.

Numerous attempts were made to get males and females to attach to a bovine, but all failed, and it is probable that as adults they never attach to warm-blooded hosts. On July 2, 5 females and 1 male were placed upon a box tortoise and all readily attached. On the second day following, 2 females had detached and were missing, apparently having been eaten by the tortoise, and on the following day a third female was also missing. The male and remaining female which were attached at the anterior part of the body of the tortoise remained attached until July 26, when the male was found to have reattached at the anterior part of the host's body. On July 27 the female commenced engorging and the following day the male was missing. On July 30, 28 days after attachment, the female had become fully engorged and was removed in order that it might not be injured or lost in dropping. This tick measured 14 by 9 by 5 mm. During attachment no signs of mating were observed; however, as eggs deposited by the female hatched, it is probable that the tick was fertilized just prior to the date that it commenced to increase noticeably in size. It thus appears that mating continues for only a very short time. The position at which the female attached and engorged was just beneath the carapace midway between the head and the left fore leg. Newstead reports 3 females to have engorged on a toad in 14, 17, and 23 days, respectively.

LIFE CYCLE.

Larvæ may live 95 days in summer and fall; they engorge as soon as 4 days and in summer may molt as soon as 7 days, at least 305° F. of effective temperature being required. Nymphs may live as long as 130 days during summer and fall; they engorge as soon as 5 days after attaching to a host, and may molt in 12 days after dropping, 479° F. of effective temperature being required. Among the individuals which we have observed to molt from nymphs, there was a predominance of females. Adults may live 129 days; they may engorge in 14 days, commence ovipositing 6 days later, and deposit as many as 1,784 eggs. In summer eggs may hatch in 27 days, 1,133° F. of effective temperature being required. The longevity of all stages of this tick appears to be shorter than any of the Amblyommas studied by us with the possible exception of *A. tuberculatum*.

ECONOMIC IMPORTANCE.

So far as is now known this tick is of no economic importance. However, a better knowledge of the host relations of the species may show it to be of some importance.

NATURAL CONTROL.

No natural enemies of this tick have been found by us.

THE GULF COAST TICK.

Amblyomma maculatum Koch.

DESCRIPTIVE.

The common name of this species is given because of the prevalence of the tick along the Gulf coast.

Adult (Pl. X, figs. 8–10).—Males from 4 by 2.25 mm. to 6 by 3 mm. Females, unengorged, 4 by 2.25 mm. to 5 by 2.33 mm.; engorged, from 14 by 10 by 7 mm. to 18 by 13 by 8 mm. Males dark brown, scutum brown, lineate with silvery white, lines more or less connected. Unengorged females dark brown, scutum silvery white behind, brown in front, with one median and two lateral interrupted stripes. Engorged females leaden gray.

Nymph (Pl. X, fig. 7).—Unengorged, about 1.33 by 0.75 mm.; engorged, about 4.5 by 3 by 2 mm. Dark bluish gray, shining; some of the engorged nymphs are dull white, due to the ingestion of lymph. Capitulum 0.392 mm. long (from tip of palpi to base of emargination of scutum); scutum 0.617 mm. long by 0.598 mm. wide.

Larva (Pl. X, fig. 6).—Unengorged, 0.617 by 0.402 mm. to 0.631 by 0.416 mm.; engorged, 1.5 to 1.66 mm. long by 1 mm. wide.

Color brown, lateral margins of scutum with a dark red marking. Some engorged specimens are pink colored at the time of dropping; a few are dull white, but the greatest number are dark gray. Capitulum 0.136 mm. long (from tip of palpi to base of emargination of scutum); scutum 0.23 mm. long by 0.33 mm. wide.

Egg.—Ellipsoidal, brownish yellow, smooth, shining. The maximum size of 10 eggs measured was 0.539 by 0.385 mm., minimum size 0.508 by 0.400 mm., and average size 0.520 by 0.397 mm.

HOST RELATIONSHIP.

The type host is not known. Records of 49 collections have been made in Texas and Louisiana by agents of the bureau. Of these, 12 were on dog, 11 on cattle, 8 on horse, 7 on meadowlark, 3 on sheep, 2 on goats, 1 on man, 1 on wolf, 1 on fox, 1 on quail, 1 on red-winged blackbird, and 1 on jack rabbit. A deer and a beetle have also been recorded as hosts. The larvæ of this species have not been collected by us on hosts in nature. Birds probably act as hosts for the larvæ and are undoubtedly common hosts of the nymph. Of the above-mentioned collections, the seven lots of this species on meadowlarks and the last four lots listed were all nymphs. Cattle and dogs appear to be the most common hosts of the adults, although, as is indicated by the host list given above, the species has no decided host limitations.

GEOGRAPHICAL DISTRIBUTION.

(Fig. 10.)

The type locality is "Carolina." The species occurs commonly along the Gulf Coast from Cameron Parish, La., to the Rio Grande in Texas. It has been taken inland as far as Columbus, Victoria, and Laredo, Tex. A single male was collected on a dairy cow at Dallas, Tex. No cattle had recently been brought to this dairy from other points. Five lots have been collected by agents of the bureau on dogs at Orlando, Fla. The Marx collection contains a male specimen (labeled by Marx) from Tulare County, Cal. The Marx collection also contains a male and an unengorged female, labeled Memphis, Tenn. It seems quite probable that in these two latter instances the ticks were carried on cattle which were shipped inland. Prof. H. A. Morgan has called attention to the fact that the ticks collected by Niles (1898, pp. 28, 29) in Virginia and referred to as *Dermacentor occidentalis* belong to this species.

Outside of this country this tick is known to occur in Mexico, Jamaica, Ecuador, Peru, Brazil, Paraguay, Chile, and Argentina.

LIFE HISTORY.

Observations on the biology of this species have been made by Lahille (1905), Hunter and Hooker (1907), Hooker (1908), and Newstead (1909).

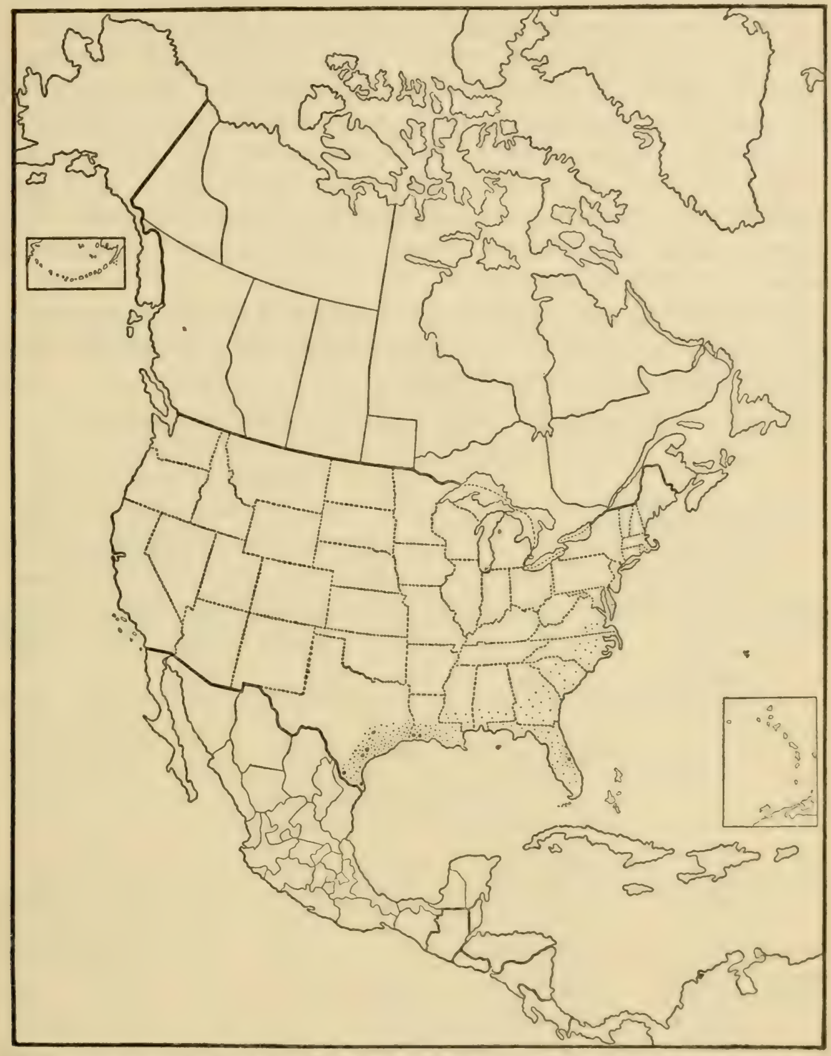


FIG. 10.—The Gulf Coast tick. *Amblyomma maculatum:* Distribution in the United States. The large dots show localities where the species has been collected in our investigation. The small dots indicate the probable range of the species. (Original.)

The egg (Table LIII).—In May and September at a mean temperature of 74° F. oviposition commenced as soon as the third day after dropping. The largest number of eggs deposited by any one of the seven females observed was 11,265, the smallest number

4,560, with an average of 8,282. The female which deposited the maximum number of eggs measured 17 by 12 by 6 mm. This female began depositing on the third day after dropping (September 1, 1907), and deposition was completed in 16 days, 1,793 eggs having been deposited on one day. The individual which deposited the smallest number of eggs was the largest tick observed by us, measuring 18 by 3 by 8 mm. The cool weather which followed the dropping of this tick caused an interrupted and prolonged period of deposition and a considerable reduction in the total number of eggs deposited. Four females, engorged on a bovine, measured 14 by 10 by 7 mm., 18 by 11.5 by 8 mm., 15 by 10.5 by 7 mm., and 18 by 12 by 7 mm., respectively. Others were engorged on a horse and on a sheep. The preoviposition period varied from 3 to 9 days and the deposition period from 13 to 75 days.

The minimum incubation period in May at a mean temperature of 81° was 21 days. An effective temperature of 793° F. appears to be required for embryonic development.

TABLE LIII.—*Incubation and larval longevity of Amblyomma maculatum.*

Eggs deposited.	Hatching began.	Minimum incubation period.	All larvæ dead.	Larval longevity.	Temperature during incubation.			
					Maximum.	Minimum.	Average daily mean.	Total effective.
1908.	1908.	*Days.*	1908.	*Days.*	°*F.*	°*F.*	°*F.*	°*F.*
May 20	June 10	22	Sept. 24	107	90	68	79.5	803.25
May 21	June 11	22	...do......	107	90	68	79.2	797.25
May 30	June 19	21	...do......	98	91.5	69	81	793.75
	1909.		1909.					
Nov. 25	Mar. 6	102	June 6	92	87	17	59.22	1,654.00
1909.								
Oct. 8	Nov. 28	52	Mar. 17	116	94	41	70.05	1,406.50
AT OUTDOOR TEMPERATURE.								
1906.	1906.		1907.					
Sept. 5	Oct. 6	....	Feb. 18	136	....	....	....	....
Sept. 7	...do....	....	Apr. 1	179	....	....	....	....
Sept. 9	...do.....	28	Jan. 23	110	95	42	77.4	963.20
			1906.					
Sept. 11	Oct. 7	27	Dec. 8	63	95	42	76.68	909.36
1908.	1908.		1909.					
Aug. 23	Sept. 16	24	Mar. 3	168	100	59	83.4	969.60
	1909.							
Oct. 3	Feb. 20	141	June 8	108	89	10	60.98	1,201.65
Oct. 2	...do....	142	June 17	117	89	10	61.01	1,224.25

The larva (Tables LIII–LIV).—The longevity of larvæ hatched October 6, 1906, was 179 days, which was the maximum period observed by us. This lot of ticks was kept out of doors.

The shortest period in which larvæ engorged was 3 days, over 92 per cent of them dropping on the fourth and fifth days following attachment.

TABLE LIV.—*Engorgement of larvæ of Amblyomma maculatum.*

Date larvæ applied.	Host.	Larvæ dropped engorged—days following application.										Total number dropped.
		1	2	3	4	5	6	7	8	9	10	
1906.												
Oct. 9	Dog	0	0	0	0	1	0	0	0	0	0	1
1907.												
Sept. 23	Bovine	0	0	1	65	23	9	1	0	0	0	99
Oct. 29	do	0	0	0	(1)	29	7	3	0	0	0	39
1908.												
Mar. 27	do	0	0	1	115	51	0	0	0	0	0	167
July 18	do	0	0	0	3	14	2	0	0	0	0	19
July 24	do	0	0	0	1	13	1	1	0	0	0	16
Aug. 18	do	0	0	0	0	2	0	0	0	0	0	2

[1] Larvae which molted on this day were included with those which molted on the following day.

At a mean temperature of 85.7° F. molting began as soon as 7 days. One of 7 larvæ which dropped November 4, 1908, molted 121 days later. The mean temperature during this period was about 60.8° F. An effective temperature of at least 299° F. is required for molting.

The nymph (Table LV).—There are no records at hand on the longevity of the free nymph.

Engorgement took place as soon as 5 days, 75 per cent dropping on the sixth and seventh days after attachment. The longest engorgement period observed was 11 days. The tick upon which this record was made was collected on a meadowlark and placed upon a rabbit about a month later, when it readily attached.

TABLE LV.—*Engorgement of nymphs of Amblyomma maculatum.*

Date nymphs applied.	Host.	Nymphs dropped engorged—days following application.											Total number dropped.
		1	2	3	4	5	6	7	8	9	10	11	
Oct. 27, 1907	Dog	0	0	0	0	0	0	2	0	0	0	0	2
Oct. 29, 1907	Bovine	0	0	0	0	3	8	5	1	0	0	0	17
Nov. 1, 1907	Dog	0	0	0	0	1	0	0	0	0	0	0	1
Aug. 11, 1908	Bovine	0	0	0	0	0	3	0	0	0	0	0	3
Mar. 27, 1909	Rabbit	0	0	0	0	0	0	0	0	0	0	1	1

The shortest molting period recorded for nymphs is 17 days. This record is based upon specimens which dropped August 17, 1908. The mean temperature was 84° F. and the total effective temperature 694° F. during the period. There was considerable variation in the molting periods of ticks dropped in November which were kept under nearly the same conditions, the shortest period being 51 days and the longest 71 days.

The adult (Tables LVI, LVII).—Two-thirds of the 24 adults, the molting of which was observed by us, were females. The greatest adult longevity recorded was between 388 and 411 days. These ticks were kept on moist sand in the laboratory. The longevity of the sexes appears to be about the same.

TABLE LVI.—*Longevity of adults of Amblyomma maculatum.*

Molted.				Date last tick died.	Longevity in days.
Date.	Male.	Female.	Total.		
1907.				1908.	
December	2	2	4	Dec. 6	365±
Dec. 30	1	1	2	Jan. 22–Feb. 14	388–411
1909.				1910.	
May 3	1	0	1	Nov. 28	209
May 4–5	1	1	2	Sept. 26–Oct. 18	144–167
May 5	0	1	1	Sept. 26	144

Males and females that had been reared from nymphs when placed upon the host attached quite readily. Twelve days passed, however, before they were found in copulation. After a male mates with a female it usually remains with her until she drops; it then goes in search of another mate. Mr. J. D. Mitchell states that he has observed the sexes in copulation after having been removed from the host.

Engorgement has been found to take place as soon as 14 days. Partially engorged females reattach if they have not been injured in being removed. The largest specimen which we have observed was collected partially engorged from a sheep; it reattached and engorged upon a bovine. This specimen remained attached for a day and a half after being apparently fully engorged. Upon removal it was found to weigh 1 gram and to measure 18 by 13 by 8 mm. Next to *Amblyomma tuberculatum* this is the largest species that occurs in the United States.

TABLE LVII.—*Engorgement of females of Amblyomma maculatum.*

Adults applied.	Host.	Females dropped engorged.	Period of attachment.	Size engorged.
1908.		1908.	*Days.*	
Apr. 27	Bovine	May 11	14	14 by 10 by 7 mm.
Do	do	May 12	15	18 by 11.5 by 8 mm.
Apr. 27 (2)	do	May 14 (2)	17	15 by 10.5 by 7 mm.
Apr. 27	do	May 15	18	18 by 12 by 7 mm.

Males remain attached for long periods after the females drop and may mate with several females. This habit of remaining upon the host after the females have dropped accounts for so many males being taken at certain seasons of the year when females can not be found. On August 28, 1907, Mr. J. D. Mitchell of this bureau examined the ears of 340 cattle at a branding chute in Goliad County, Tex., and found 4 females and about 100 males, none of these being in coitu. The males were frequently in clusters, as many as 9 being counted in one cluster, 5 or 6 being a frequent number. The following day Mr. Mitchell examined the ears of 933 cattle in Refugio County, Tex., and found 15 females and several hundred males. In two instances specimens were found in coitu. Many of the males were in clusters of from 5 to 10. In another locality 567 cows were examined, 1 female tick and 3 males being found, all on different animals. Our records show that males were removed from hosts a month after all the females had dropped, and it is probable that they remain on the host for a number of months. As with some other species, the males, having once fed, do not appear to live long after leaving the host. Thus 2 males removed from the host a month after the females had dropped lived less than a month, one dying in 10 days, although kept under the most favorable conditions.

This species attaches largely to the head, particularly to the ears both on the inside and outside.

LIFE CYCLE.

Larvæ may live for 6 months during the winter and for 112 days in summer; they engorge as soon as 3 days after application to a host and molt as soon as 7 days after dropping. A total effective temperature of 399° F. is necessary to produce this molt. Nymphs engorge as soon as 5 days after application and molt as soon as 17 days after dropping, a total effective temperature of 694° F. being required to produce this transformation. Adults may live for 388 days; they mate upon the host, may engorge as soon as 14 days after attachment, and begin ovipositing the third day after dropping. Eggs hatch as soon as 21 days after deposition, a total effective temperature of 793° F. being required for incubation. Although adults may be found at any time during the year they appear to be much more numerous in the summer and early fall than at other seasons. The nymphs are to be found in considerable numbers upon birds in February and March.

ECONOMIC IMPORTANCE.

In the sections where this tick occurs in any numbers it is the source of great annoyance to domestic animals, particularly to cattle. By attaching to the inside of the ears, as frequently occurs, great irritation is caused; in the case of calves, this irritation is sufficient to cause suppuration and the formation of large scabs. The injury in the ears furnishes opportunity for the screw-worm fly (*Chrysomyia macellaria*) to deposit its eggs, which in the case of equines sometimes results in the destruction of the cartilage, thus causing the ears to droop—a condition known as "gotched" ears. The species is also of some importance on account of the fact that it sometimes attacks man.

NATURAL CONTROL.

The natural enemies of the cattle tick undoubtedly destroy many ticks of this species.

ARTIFICIAL CONTROL.

The longevity and numerous hosts of this tick make starvation impractical. Where the injury is sufficiently great to warrant artificial checks, hand picking, mopping, or dipping should be resorted to. Animals should be treated as often as every 12 days in order to prevent the females from engorging.

THE LONE STAR TICK.

Amblyomma americanum (Linnæus).

This species receives its common name from the silvery spot on the apex of the scutum of the female.

DESCRIPTIVE.

Adult (Pl. XI, figs. 2, 3, 5–10).—Males from 2.5 by 1.5 mm. to 3.5 by 2.5 mm. Females, unengorged, 3.5 by 2 mm. to 4 by 2.25 mm.; engorged, 10 by 9 by 5 mm. to 15 by 12 by 8 mm. Color brown; posterior lobe of the scutum of the female with a large silvery white spot; the dorsum of the male also has silvery white markings around its posterior margin.

Nymph (Pl. XI, fig. 4).—Unengorged, about 1.5 by 1.25 mm.; light brown, with much yellow (fulvous), scutum somewhat darker; the intestines, which show through, appear to be of a dark brown color; length of capitulum 0.41 mm. (from tip of palpi to base of emargination of scutum); scutum 0.86 mm. long by 0.699 mm. wide; engorged, about 4 by 2.5 mm. in the larger specimens, which usually become females, and 3 by 2 mm. in the smaller, which usually become males; color dark gray. The silvery white markings of the males and females do not become visible until a day or two prior to the shedding of the skin.

Larva (Pl. XI, fig. 1).—Unengorged, 0.64 by 0.51 mm.; length of capitulum 0.185 mm. (from tip of palpi to base of emargination of scutum); scutum 0.235 mm. long by 0.332 mm. wide; body ovoid, brown, lateral margin of scutum darker brown. Engorged, 1.5 by 1 mm., ovoid. Most of the larvæ as they drop engorged are dark brown, shining, but some have a pink color.

Egg.—Ellipsoidal, yellowish brown to pale yellow, or pale brownish yellow, shining, smooth. The maximum size of 10 was 0.570 by 0.431 mm.; minimum size 0.514 by 0.416 mm.; average size 0.544 by 0.419 mm.

HOST RELATIONSHIP.

The type host for this species is not known. The species has a wide range of hosts, apparently attaching to almost any mammal with which it comes in contact. It has also been taken from birds. In about 75 records of collections of this species in the southwestern part of the United States, largely in Texas, the frequency of occurrence on different hosts was as follows: Dog 23, cattle 11, man 9, horse 9, deer 4, goat 3, peccary 2, hog 2, mule 2, skunk 2, sheep 1, wolf 1, fox squirrel 1, badger 1, domestic cat 1, wild turkey 2, and chaparral cock 1.

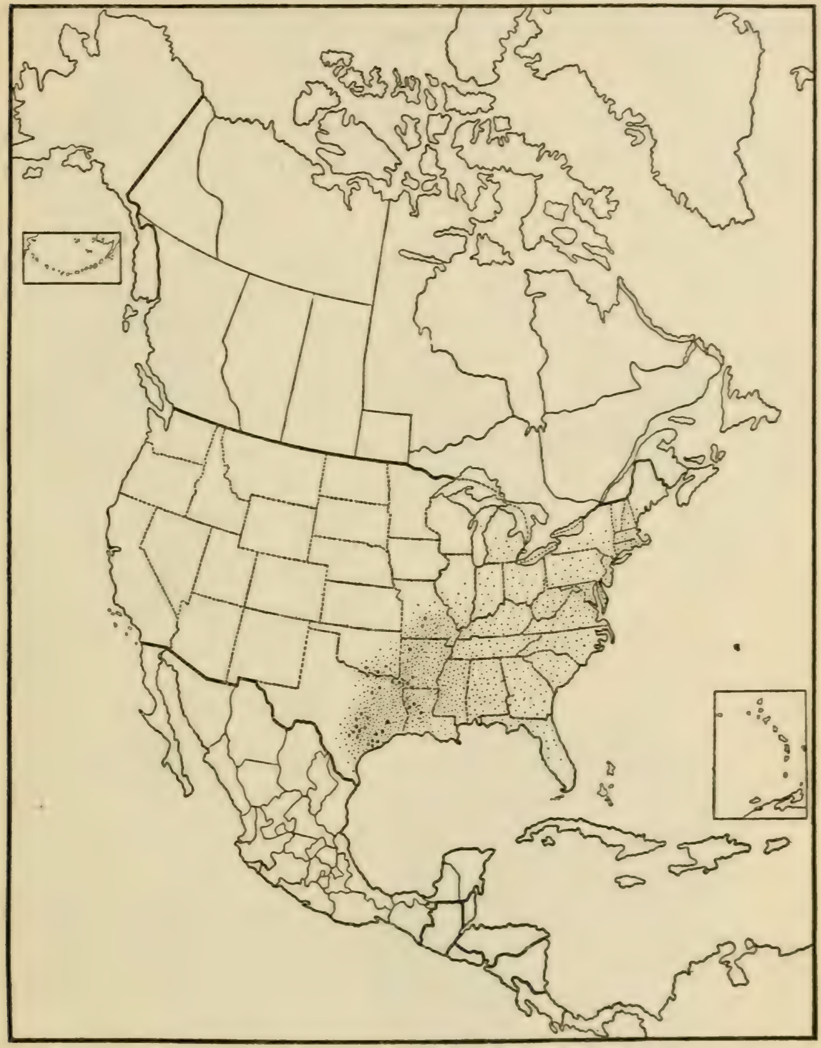


FIG. 11.—The lone star tick, *Amblyomma americanum:* Distribution in the United States. The large dots show localities where the species has been collected in our investigation. The small dots indicate the probable range of the species. (Original.)

GEOGRAPHICAL DISTRIBUTION.

(Fig. 11.)

The type locality for this species is Pennsylvania or New Jersey. The Marx collection contains one unengorged female from Labrador. The species has been collected from nearly all of the States bordering upon the Atlantic Ocean and Gulf of Mexico and from several inland States, including Michigan, Kentucky, Missouri, Arkansas, and Oklahoma. It is also reported to have been collected in Guatemala, Guiana, and Brazil. The species is very abundant in a large part of the States of Texas and Louisiana.

LIFE HISTORY.

Information on the biology of this species has been published by Leidy (1891), Morgan (1899), Hunter and Hooker (1907), and by Hooker (1908).

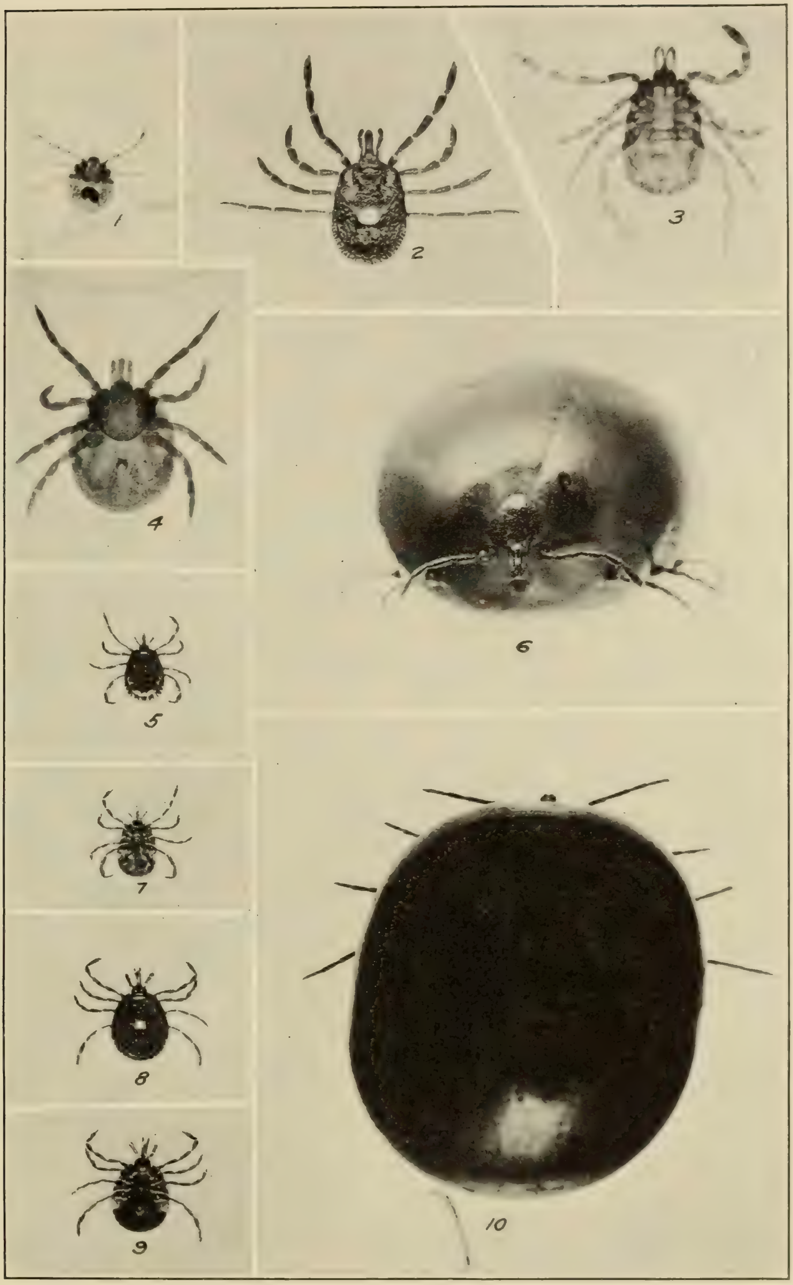
The egg (Tables LVIII, LIX).—In the laboratory in June at a mean temperature of 87.7° F. oviposition commenced as early as the fifth day from dropping, while out of doors in July and August at a mean temperature of about 81° F. seven or more days were required. The longest preoviposition period recorded was 13 days. At a mean temperature of 80° F. one tick continued oviposition for 23 days. This individual, however, was one of the largest met with (measuring 15 by 12 by 8 mm.) and deposited the maximum number of eggs recorded for the species, namely, 8,330 eggs between May 25 and June 16. The maximum, minimum, and average preoviposition period for 12 ticks, the deposition of which is recorded in Table LVIII, was 9, 5, and 7 days, respectively. The maximum, minimum, and average oviposition period for these ticks was 23, 8, and 13.25 days, respectively, and the average number of eggs deposited was 3,053.5 per tick.

TABLE LVIII.—*Oviposition of Amblyomma americanum.*

Date engorged female dropped.	Number of eggs deposited—days following dropping.											
	6	7	8	9	10	11	12	13	14	15	16	17
1906.												
April 27	0	0	110	74	31	118	89	230	399	503	464	338
May 15	0	0	0	0	178	383	583	213	465	356	230	73
Do	0	0	390	417	656	835	963	50	(1)	572	229	201
Do	0	(1)	414	285	504	594	361	210	(1)	156	66	55
Do	0	0	193	301	409	271	197	82	(1)	144	24	64
Do	0	0	180	187	209	144	99	57	(1)	53	14	4
Do	0	0	58	206	380	368	187	53	(1)	118	36	36
Do	0	0	42	201	307	264	197	110	(1)	89	41	39
1908.												
May 6	0	0	0	0	54	435	464	501	496	622	323	342
Do	0	0	0	0	32	445	439	589	248	745	219	239
May 7	0	57	270	265	367	335	420	354	364	330	195	67
May 19	(1)	460	757	766	805	730	808	714	647	615	467	635

[1] The eggs laid on this day are included with those recorded under the following day.

PLATE XI.



THE LONE STAR TICK, AMBLYOMMA AMERICANUM.

Fig. 1.—Unengorged larva. Fig. 2.—Unengorged female, dorsal view. Fig. 3.—Male (balsam mount). Fig. 4.—Unengorged nymph (balsam mount). Fig. 5.—Male, dorsal view. Fig. 6.—Engorged female, frontal view. Fig. 7.—Male, ventral view. Fig. 8.—Unengorged female, dorsal view. Fig. 9.—Unengorged female, ventral view. Fig. 10.—Fully engorged female, dorsal view. (Original.)

TABLE LVIII.—*Oviposition of Amblyomma americanum*—Continued.

Date engorged female dropped.	Number of eggs deposited—days following dropping.											Total number of eggs.
	18	19	20	21	22	23	24	25	26	27	28	
1906.												
April 27	212	132	112	70	0	Dead	....	....	....	....	....	2,882
May 15	0	0	0	27	0	...do...	....	....	....	....	....	2,505
Do	148	129	0	0	Dead	....	....	....	....	....	....	4,590
Do	14	0	0	0	...do...	....	....	....	....	....	....	2,659
Do	25	17	6	3	0	0	....	....	....	....	....	1,736
Do	0	0	0	0	Dead	....	....	....	....	....	....	947
Do	25	20	16	5	2	0	....	....	....	....	....	1,510
Do	6	10	0	0	Dead	....	....	....	....	....	....	1,306
1908.												
May 6	196	103	106	90	19	0	Dead	....	....	....	....	3,751
Do	162	54	2	0	0	0	...do...	....	....	....	....	3,174
May 7	74	67	79	5	0	0	...do...	....	....	....	....	3,249
May 19	186	203	153	100	76	58	51	38	25	22	14	8,330
Average	......	......	......	......	....	....	....	....	....	....	....	3,053.

The minimum incubation period recorded occurred in the laboratory in June and July at a mean temperature of 80.5° F. This period was 23 days, while out of doors in July and August, at a mean temperature of 82.5° F., 32 days passed before hatching commenced. The total effective temperature required for embryonic development appears to be 862° F.

TABLE LIX.—*Preoviposition, incubation, and larval longevity of Amblyomma americanum.*

Date engorged female dropped.	Eggs deposited.	Hatching began.	Minimum incubation period.	All larvæ dead.	Larval longevity.	Temperature during incubation.			
						Maximum.	Minimum.	Average daily mean.	Total effective temperature.
	1906.		*Days.*	1906.	*Days.*	*°F.*	*°F.*	*°F.*	*°F.*
	May 28, 29	Before July 1	34	Nov. 27	150	......	......	......	......
	May 30, 31	July 1 or before	32	Nov. 27	150	......	......	......	......
1907.	1907.	1907.							
Mar. 30	Apr. 12	June 13	63	....	....	......	......	......	......
June 18	June 25	July 22	28	....	....	......	......	......	......
	1908.	1908.		1908.					
	May 14, 18	June 11	29	Sept. 30–Oct. 7	110–115	89.0	65	78.5	1,028
	May 19–27	June 15	28	Oct. 16–24	123–131	91.5	68	79.7	1,018
	May 27–29	June 21	26	Before Sept. 24	95	91.5	69	80.4	972
	May 30	June 24	26	Sept. 30–Oct. 7	98–105	91.5	69	81	986
	May 31–June 3	June 26	27	Sept. 25	91	91.5	69	81.2	1,019
	June 4–6	June 29	26	Oct. 26	119	91.5	69	80.8	983
1909.	1909.	1909.		1909.					
June 4	June 10	July 4	25	....	....	91.0	69	80.2	930
	June 11	July 3	23	Sept. 2–15	61–74	91.0	70	80.5	862
	June 9	July 3	25	Aug. 20–Sept. 2	48–61	91.0	69	80.3	932
June 9	June 15	July 9	25	Sept. 4–15	57–68	90.0	71	81	950
		1910.		1910.					
Sept. 27	Oct. 11	Jan. 27	109	May 20–July 16	113–170	87.0	17	57.1	1,908
Oct. 2	Oct. 14	Feb. 7	117	July 16–Aug. 2	159–176	87.0	17	56	1,949
	1908.	1908.		1909.					
[1]	July 14	Aug. 14	32	Apr. 19	279	97.5	60	82.3	1,256
[1]	July 16	Aug. 16	32	Jan. 28–Feb. 8	196–207	97.5	60	82.5	1,262
[1]	July 17	Aug. 17	32	Dec. 24 (1908)–Jan. 23	160–190	97.5	60	82.5	1,264

[1] Records made out of doors.

The larva (Tables LIX–LXI).—As is shown in Table LIX, the greatest longevity of larvæ observed by us was 279 days. This record was made on ticks kept in a tube in a protected place out of doors. The longevity of larvæ kept in the laboratory did not exceed 176 days and usually ranged between two and four months. Larval engorgement was completed as soon as 3 days, the greatest number dropping from the host on the fourth day. The longest period required for engorgement was 9 days; this, however, may be explained through the failure of the ticks to attach at once or because they attached at a point where the blood supply was poor.

TABLE LX.—*Engorgement of larvæ of Amblyomma americanum.*

Date larvæ applied.	Host.	Larvæ dropped engorged—days following application.										Total number dropped.
		1	2	3	4	5	6	7	8	9	10	
July 12, 1907, 3 p. m.	Bovine	0	0	80	177	7	0	0	0	0	0	264
Apr. 6, 1908, 4 p. m.	...do	0	0	0	0	6	6	0	2	1	0	15
July 27, 1908, 5 p. m.	...do	0	0	0	80	13	0	0	0	0	0	93
Aug. 31, 1908, 3 p. m.	Rabbit	0	0	0	61	21	10	4	0	0	0	96
Aug. 16, 1909	Bovine	0	0	0	0	11	10	0	0	0	0	21

The rapidity of engorgement is shown in Table LXI:

TABLE LXI.—*Rapidity of engorgement of larvæ of Amblyomma americanum applied to bovine at 3 p. m., July 12, 1907.*

Date engorged larvæ dropped (bags examined).	Number.	Period from application.	Per cent of total dropped.
1907.		*Hours.*	
July 15, 11 a. m.	26	68	9.8
July 15, 3 p. m.	51	72	19.3
July 15, 4.30 p. m.	3	73½	1.2
July 16, 10 a. m.	104	91	39.4
July 16, 1.30 p. m.	69	94½	26.1
July 16, 5 p. m.	4	97½	1.5
July 17, 10 a. m.	5	114½	1.9
July 17, 2 p. m.	2	118½	.8
July 17, 5 p. m.	0	....	....
Total	264	....	....

Our observations of the molting of engorged larvæ were made on 326 individuals. In July and August at a mean temperature of 86.78° F. molting commenced in 8 days. A total effective temperature of 350° F. appears to be required for this transformation. The longest period recorded from dropping to molting was 26 days. During winter this period would undoubtedly be much longer.

The nymphs (Tables LXII–LXIV).—The most complete information at hand on the longevity of nymphs was obtained in an experiment in which 30 nymphs that molted June 23–26, 1907, were kept out of doors in a tube that had a cork stopper, through which a small hole had been made and a small glass tube inserted to permit an equalization of the humidity content of the air. Over the small glass tube a cotton cloth was tied to prevent the escape of the ticks. The records show that on May 6, 1908, 6 were alive and very active; from July 28 to August 29, 5 were found alive; from September 3 to September 10, 4; from September 18 to September 23, 3; from September 28 to October 1, 2. The sole survivor died on October 11, 1908, a period of 476 days or 15½ months after having transformed to a nymph.

TABLE LXII.—*Longevity of nymphs of Amblyomma americanum.*

Date molted or collected.	Number.	Date last larva died.	Nymphal longevity.
			Days.
June 23–26, 1907, molted	30	Oct. 11, 1908	176
Aug. 11, 1908, molted	6	Apr. 18, 1909, 1 alive	240+
Sept. 2, 1908, molted	6	June 24 to July 13, 1909	295–314
Sept. 21, 1908, molted	3	Jan. 30 to Feb. 23, 1909	131–155
Sept. 21–23, 1908, molted	4	Jan. 22 to Feb. 12, 1909	121–144
Aug. 31 to Sept. 5, 1909, molted	15	Feb. 15, 1910, 9 alive	189–196+
Sept. 2, 1909, collected	10	Feb. 28 to May 20, 1910	207–260

The shortest period in which engorgement took place was three days, the majority dropping from the third to fifth days.

TABLE LXIII.—*Engorgement of nymphs of Amblyomma americanum.*

Date nymphs applied.	Host.	Nymphs dropped engorged—days following application.										Total number dropped.
		1	2	3	4	5	6	7	8	9	10	
July 27, 1907	Dog	0	0	2	0	0	0	0	0	0	0	2
July 31, 1907, 2 p. m.	Bovine	0	0	14	3	0	0	0	0	0	0	17
June 15, 1908, 5 p. m.	do	0	0	0	0	1	1	0	1	0	0	3
Aug. 20, 1908, 6 p. m.	do	0	0	4	8	7	0	0	0	0	0	19
Aug. 31, 1908, 3 p. m.	Rabbit	0	0	0	7	3	0	0	0	0	0	10
Mar. 15, 1910	Bull	0	0	0	0	0	1	0	1	0	0	2
Sept. 7, 1910	do	0	0	1	0	2	1	0	2	0	0	6

In August, 1907, molting commenced on the thirteenth day. In August, 1908, at a mean temperature of 84° F. molting commenced as soon as 16 days after dropping, a total effective temperature of 657° F. being required. The longest period from dropping to molting recorded was 46 days. Winter temperatures lengthen the molting period considerably.

TABLE LXIV.—*Molting of engorged nymphs of Amblyomma americanum.*

Date engorged nymphs dropped.	Host.	Number.	Engorged nymphs molted—days following dropping.																	
			13	15	16	17	18	19	20	21	22	23	24	25	26	28	31	32	45	46
Aug. 3, 1907	Bovine	14	0	2♂	1♂ 5♀	1♂ 3♀	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aug. 4, 1907	do	3	1♂	0	2♀	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
June 16, 1908	Horse	1	0	0	0	0	0	1♀	0	0	0	0	0	0	0	0	0	0	0	0
June 20, 1908	Bovine	1	0	0	0	0	0	0	0	1♂	0	0	0	0	0	0	0	0	0	0
June 21, 1908	do	1	0	0	0	0	0	0	1♂	0	0	0	0	0	0	0	0	0	0	0
June 23, 1908	do	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1♀
Aug. 21, 1908	Dog	4	0	0	0	1♂ 1♀	2♀	0	0	0	0	0	0	0	0	0	0	0	0	0
Aug. 23, 1908	Bovine	4	0	0	0	3♀	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aug. 24, 1908	do	8	0	0	0	1♂ 1♀	1♂	1♂ 1♀	1♂	1♂	1♂	0	0	0	0	0	0	0	0	0
Aug. 25, 1908	do	7	0	0	1♂	1♂	1♂	2♂ 1♀	1♀	0	0	0	0	0	0	0	0	0	0	0
Sept. 4, 1908	Rabbit	6	0	0	0	0	0	0	0	0	1♀	2♀	1♂ 1♀	0	0	0	0	0	0	0
Sept. 2, 1909	Bovine	12	0	0	1♂	1♂	4♂ 4♀	0	0	0	0	0	0	0	0	0	0	0	0	0
Sept. 10, 1909	Bull	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1♂	0	0	0	0
Sept. 12, 1909	do	2	0	0	0	0	0	0	0	0	0	0	0	2♀	0	0	0	0	0	0
Sept. 13, 1909	do	1	0	0	0	0	0	0	0	0	0	0	0	1♀	0	0	0	0	0	0
Sept. 15, 1909	do	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1♀	1♀	0	0
Mar. 21, 1910	do	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1♂	0
Mar. 23, 1910	do	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1♂	0
Total		70																		

[♂=Male. ♀=Female.]

Date engorged nymphs dropped.	Host.	Number.	Number molted.			Temperature from dropping to date first tick molted.		
			Male.	Female.	Total.	Maximum.	Minimum.	Average daily mean.
						°F.	°F.	°F.
Aug. 3, 1907	Bovine	14	4	8	12			
Aug. 4, 1907	do	3	1	2	3			
June 16, 1908	Horse	1	0	1	1	90.0	70.5	80.96
June 20, 1908	Bovine	1	1	0	1	93.5	70.5	81.52
June 21, 1908	do	1	1	0	1	93.5	70.5	81.57
June 23, 1908	do	1	0	1	1	99.0	75.0	83.60
Aug. 21, 1908	Dog	4	1	3	4	97.5	75.0	83.72
Aug. 23, 1908	Bovine	4	0	3	3	97.5	75.0	83.96
Aug. 24, 1908	do	8	6	2	8	97.5	75.0	84.04
Aug. 25, 1908	do	7	5	2	7	97.5	75.0	84.19
Sept. 4, 1908	Rabbit	6	1	4	5	97.0	70.0	81.1
Sept. 2, 1909	Bovine	12	6	4	10	101.0	68.5	86.6
Sept. 10, 1909	Bull	1	1	0	1	101.0	56.0	79.3
Sept. 12, 1909	do	2	0	2	2	98.5	56.0	75.6
Sept. 13, 1909	do	1	0	1	1	96.5	56.0	75.2
Sept. 15, 1909	do	2	0	2	2	95.5	52.5	75.6
Mar. 21, 1910	do	1	1	0	1	92.0	43.0	86.2
Mar. 23, 1910	do	1	1	0	1	89.0	43.0	86.2
Total		70	29	35	64			

The adult (Tables LXV–LXVI).—The greatest longevity of adults recorded was between 393 and 430 days. The longevity records given below were based upon adults kept in cotton-stoppered glass tubes on moist sand in the laboratory. It is quite probable that the longevity would have been greater had the ticks been kept out of doors. The females appear to live longer usually than the males. The first lot of ticks recorded in the table is the only one in which the last surviving tick was a male.

TABLE LXV.—*Longevity of adults of Amblyomma americanum.*

Date nymphs molted to adults.	Number.			Date last tick died.	Longevity.
	Total.	Male.	Female.		*Days.*
June 5, 1908	3	2	1	Dec. 26, 1908	207
Sept. 1, 1908	8	1	7	May 15–June 8, 1909	256–280
Sept. 11, 1908	10	6	4	Jan. 22–Feb. 18, 1909	133–160
Sept. 26–28, 1908	5	1	4	Aug. 20, 1909, 1 female alive	326–328+
Sept. 10–20, 1909	11	4	7	Oct. 18–Nov. 14, 1910	393–430
Oct. 7–17, 1909	6	1	5	Aug. 18–Sept. 26, 1910	305–354

Mr. J. D. Mitchell once observed this species in copulation on herbage but we have no other record of such a habit. Ticks which have been kept together in tubes have never been observed in copulation. When unfed ticks are placed upon a host, attachment usually takes place at once, the sexual instinct being manifested only after several days feeding. Fertilization may be necessary for engorgement, as females which have been collected from vegetation have attached readily, but in the absence of males have failed to engorge and have died about a month after attachment. Males placed upon the bovine scrotum upon which females of other species were attached have been found in coitu with other species (*Margaropus annulatus australis*, *Amblyomma maculatum*, and *Dermacertor nitens*) even though females of *americanum* have been attached upon the scrotum at the same time. They have, however, remained in the position of copulation with other species for periods less than 24 hours. The eggs deposited by unfertilized females are dark and shriveled up. Our observations seems to indicate that only a short time is required for the fertilization of the female as males remain in copulation for a few hours at a time, then pass to other females, or return to the same female. They are frequently found mated with fully engorged females.

Males have remained upon the scrotum for more than two and one-half months, or a month and a half after the females dropped. Females collected from a host, if not more than one-half engorged, will attach to a second host, and if fertilized while on the first host become engorged in a comparatively short time. The minimum period in which engorgement has taken place is found to be 11 days, while slightly engorged reattached ticks which had probably been fertilized while upon the first host completed engorgement in 2 days. The longest period required for engorgement was 24 days. The length of the engorgement period does not appear to influence the size of the engorged female.

TABLE LXVI.—*Engorgement of females of Amblyomma americanum on bovine.*

Adults applied.	Engorged females dropped—days following application.														Total number dropped.
	2	3	4	5	7	8	9	10	11	14	15	16	20	24	
Mar. 28, 1907, 4 p. m [1]	1														1
Mar. 22, 1907, 9 a. m [2]			1												1
Aug. 31, 1907, 5 p. m.									1		1	2	1	1	6
May 5, 1908 [3]										1					1
June 29, 1908 [3]				1	1	1		2							5
Aug. 24, 1908 [4]			1												1
June 1, 1909. [3]		1	1	2		1									5
Sept. 18, 1909 [3]							1			2					3

[1] This tick was collected Mar. 25, 1907. It was slightly engorged, measuring 5.5 by 4 mm.

[2] This tick was slightly engorged (5 by 4 mm.) and probably fertilized when collected.

[3] These were collected on a host but were not perceptibly engorged.

[4] This tick was taken from a host and was slightly engorged.

LIFE CYCLE.

Larvæ may live as long as 279 days; they may engorge as soon as 3 days and in summer molt as soon as 8 days, a total effective temperature of 350° F. being required. Nymphs may live 476 days; they engorge as soon as 3 days and may molt 13 days after dropping. A total effective temperature of 657° F. appears to be necessary to produce this molt. Adults may engorge in 9 days, commence depositing 5 days later, and deposit as many as 8,330 eggs. The eggs hatch as soon as 23 days, requiring an effective temperature of 862° F. for incubation.

ECONOMIC IMPORTANCE.

This species is of considerable economic importance as an external parasite. It readily attaches to domestic animals and man. As its mouth parts are long and permit of deep penetration, the attachment of the tick causes considerable inflammation which frequently ends in suppuration. In Texas and Louisiana, where this species is abundant, cattle in particular suffer from heavy infestation. In the Eastern and Southern States man is more frequently attacked by this than any other species. Moss gatherers in Louisiana are greatly annoyed by its attacks (Morgan, 1899). At dairies milkers are annoyed, particularly by the males which leave the cows and attach to them. This tick may attach in the ears and be the indirect cause of "gotch" in donkeys. Mr. J. D. Mitchell has observed that on hogs this tick attaches by preference to the belly, where even in the case of engorged ticks, the swelling of the skin is sufficient to almost hide them. Suppurating pustules were observed on this host where the ticks had dropped off. Attempts to transmit Texas fever by this tick have failed (Mayo, 1897; Morgan, 1899).

A correspondent in south-central Missouri reports that this tick is a serious pest to poultry there. The larvæ attack young chickens in such numbers as to kill them. He also states that the larvæ and adults are very annoying to man and domestic animals.

NATURAL CONTROL.

In order to determine the effect of water seven partially engorged females were submerged May 29, 1906, for 18 hours. After removal all became active and on May 30 were again submerged for 45 hours, only one surviving. As yet no parasites have been found to attack this tick. The natural enemies of the cattle tick, as described in Bulletin 72, undoubtedly destroy large numbers of this species.

ARTIFICIAL CONTROL.

Owing to the great longevity of the nymphs and adults, and to the many hosts which this species attacks, the rotation method of eradication is impracticable. Frequent mopping or dipping with any of the standard tick dips must be resorted to. To be effective, mopping, dipping, or hand picking should be practiced often enough to destroy the females before they become engorged; that is, every 10 days.

THE CAYENNE TICK

Amblyomma cajennense (Fabricius).

DESCRIPTIVE.

The common name of this species is taken from the locality in which it was first collected and from which the specific name was taken; that is, Cayenne, Guiana.

Adult (Pl. XII, figs. 2, 3, 5–7).—Males from 3 by 1.75 mm. to 4 by 2.50 mm. Females, unengorged, 3.5 by 2 mm. to 4.25 by 2.5 mm.; engorged, from 10 by 7 by 4 mm. to 12 by 8 by 6 mm. Males pale yellow or brownish yellow, with irregular silvery white markings or streaks, and brown or reddish brown spots, all arranged to form a definite but complex pattern. Unengorged female yellowish; scutum largely silvery, with a brown line on each margin reaching back from the eyes. Engorged females dull bluish gray, with dark purplish brown reticulations.

Nymph (Pl. XII, fig. 4).—Unengorged, 2 by 1.25 mm.; engorged, from 3.25 by 2 mm. to 4 by 2.75 mm.; length of capitulum 0.407 mm. (from tip of palpi to base of emargination of scutum); scutum 0.561 mm. long by 0.786 mm. wide. Upon emerging the nymphs are of a dark-brown color; this soon turns to light brown, with intestinal markings showing through as dark-brown bands. As with *americanum,* the sex of the nymph can be told a day or two prior to molting by the silvery markings which show through the to-be-molted skin.

Larva (Pl. XII, fig. 1).—Unengorged, 0.65 by 0.51 mm., yellowish, the scutum marked on the lateral margins with dark red; engorged, 2.5 by 2 mm., ovoid, bluish gray. Length of capitulum 0.195 mm. (from tip of palpi to base of emargination of scutum); scutum 0.248 mm. long by 0.374 mm. wide.

Egg.—Ellipsoidal, deep yellowish brown, shining, smooth. The average size of 10 eggs measured was 0.487 by 0.431 mm.

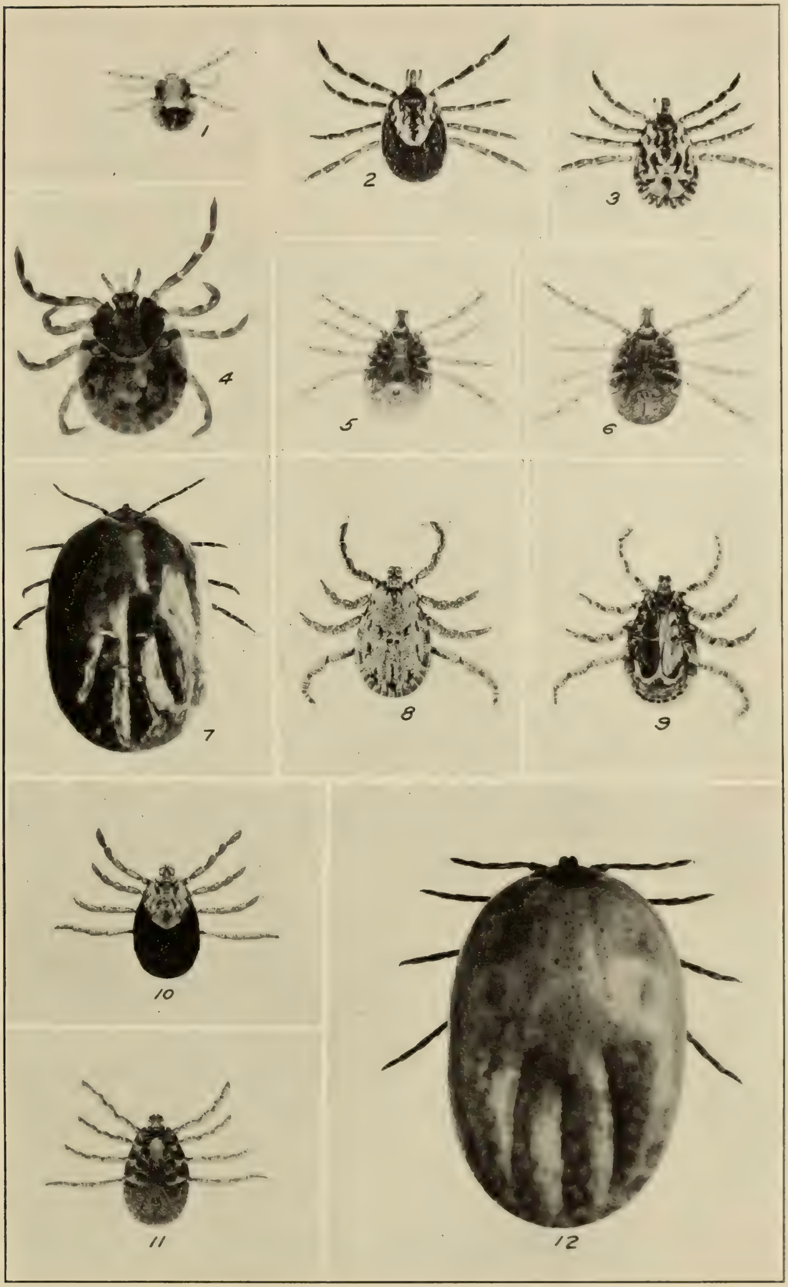
HOST RELATIONSHIP.

The type host of this tick is not known. It attaches readily to a large number of mammals, having been taken in Texas by agents of the bureau from the horse, mule, ox, goat, coyote, peccary, and man. Other hosts recorded are dog, hog, capybara, anteater, and toad. Mr. A. H. Jennings has collected this tick in Panama on the dog, horse, ox, and deer (*Odocoileus toltecus*). Mr. D. K. McMillan obtained one partially engorged female from a Mexican lion (*Felis hippolestes aztectus*) at Raymondville, Tex. On November 20, 1907, a flock of 75 goats in the vicinity of Brownsville, Tex., was examined for ticks. Larvæ of this species were found in large numbers on the ears and over the eyes of all examined, while partially engorged nymphs were occasionally found. Adults were collected in this same locality, associated with *Dermacentor nitens* in the ears of horses. However, they appear to prefer the abdomen or between the legs as places of attachment. On April 22, 1908, Mr. H. P. Wood found horses and mules at Brownsville to be badly infested by this tick. Messrs. E. A. Schwarz and F. C. Bishopp found this species to be very annoying to man in the vicinity of Tampico, Mexico. Horses appeared to be the host most commonly attacked by the adults. Newstead observed this tick in Jamaica to occur more particularly on equines and less abundantly on cattle. This has been the same in our observations. Newstead states that there are authentic records of the occurrence of this tick on the tongues of young calves. As illustrating what a great pest this tick is to man, he states that 27 adults of both sexes and swarms of larvæ were taken from his body after passing through a small native settlement in Jamaica. Stoll (1886–1893) has described a similar habit in the tick in Mexico and Central America.

GEOGRAPHICAL DISTRIBUTION.

(Fig. 12.)

The type locality of this species is Guiana. It has been collected at several points in southern Texas by agents of the Bureau of Entomology, being particularly abundant at Brownsville. The Marx collection contains an unengorged female labeled as collected at Biscayne Bay, Fla. It seems quite probable that records of this species from Arizona are based upon a jar of ticks which are incorrectly labeled. Banks records having seen specimens from San Diego County, Cal. This is, with the possible exception of *Margaropus annulatus australis,* the most common species in Mexico and Central America. It has been reported from Mexico, Guatemala, Honduras, Nicaragua, Costa Rica, Panama, Bermuda, Cuba, Jamaica, Trinidad, Colombia, Venezuela, French Guiana, Brazil, Paraguay, and Argentina.



THE CAYENNE TICK, AMBLYOMMA CAJENNENSE, AND THE PACIFIC COAST TICK, DERMACENTOR OCCIDENTALIS.

Amblyomma cajennense: Fig. 1.—Unengorged larva. Fig. 2.—Unengorged female, dorsal view. Fig. 3.—Male, dorsal view. Fig. 4.—Unengorged nymph (balsam mount). Fig. 5.—Male, ventral view. Fig. 6.—Unengorged female, ventral view. Fig. 7.—Engorged female, dorsal view. *Dermacentor occidentalis:* Fig. 8.—Male, dorsal view. Fig. 9.—Male, ventral view. Fig. 10.—Unengorged female, dorsal view. Fig. 11.—Unengorged female, ventral view. Fig. 12.—Fully engorged female, dorsal view. (Original.)

LIFE HISTORY.

Observations on the biology of this species have been made by Hunter and Hooker (1907), Hooker (1909), Rohr (1909), and Newstead (1909).

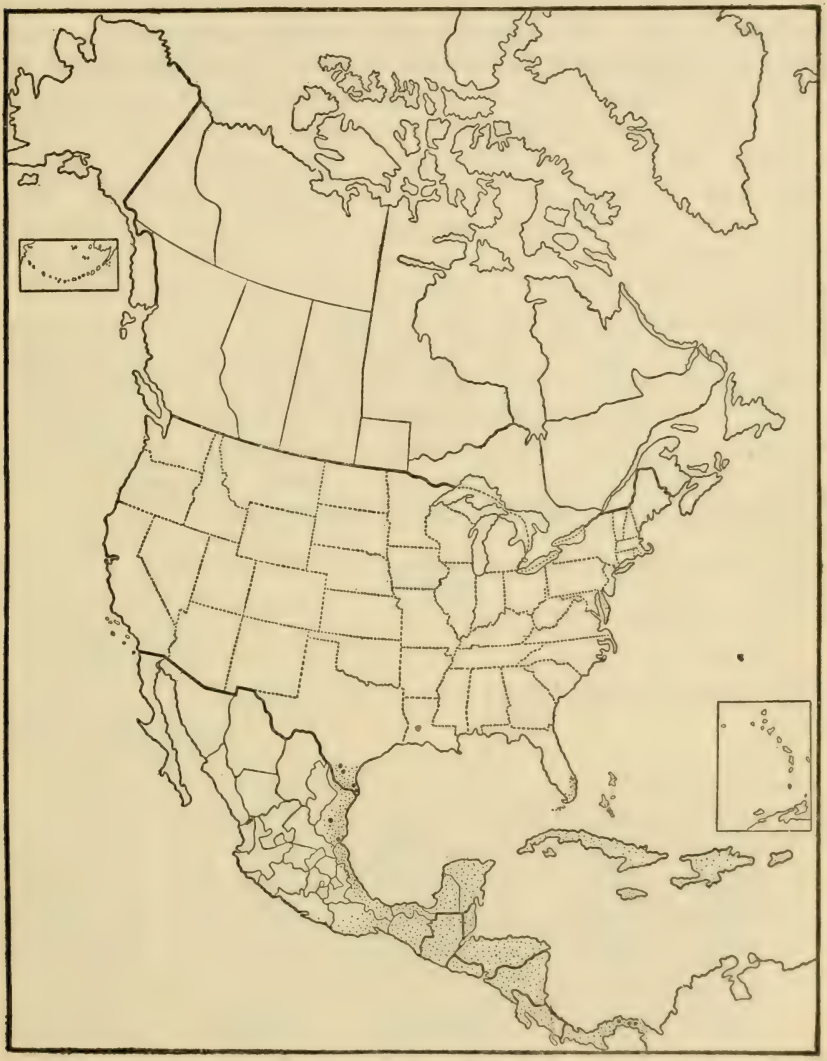


FIG. 12.—The Cayenne tick, *Amblyomma cajennense:* Distribution in North and Central America. The large dots show localities where the species has been collected in our investigation. The small dots indicate the probable range of the species. (Original.)

The egg (Table LXVII).—In the laboratory in August, at a mean temperature of 84° F., oviposition commenced on the ninth day following dropping while out of doors, at a mean temperature of 84° F., 11 days passed. Eight of 10 females collected April 22, 1908, and kept in the laboratory at a mean temperature of 63° F. commenced oviposition on the eighteenth day, the other two beginning oviposition on the sixteenth and twentieth days after collection. The average preoviposition period for 13 ticks was 16.5 days and the average oviposition period was 19.7 days. In the laboratory in May, at a mean temperature of 77° F. oviposition continued for as long as 23 days. The largest number of eggs recorded was 4,789, which were deposited in the laboratory in 20 days following May 10, 1908. The largest number of eggs deposited in 1 day was 447. The average number of eggs deposited, based upon records of 13 ticks, is 3,536. All of the females used in these counts were collected individuals and may not have been completely engorged. Newstead states that Worthly has found 7,240 eggs to be deposited by an individual of this species and Rohr records 7,742 from 1 specimen. The minimum incubation period in the laboratory at a mean temperature of 80° F. was 37 days. Out of doors, at a mean temperature of 78.5° F., 54 days passed before the eggs hatched. Under similar out-of-doors conditions, when the mean temperature was 66.2° F., the incubation period was 154 days. The effective temperature required for embryonic development appears to be 1,370°. Newstead reports that at an average temperature of 75° F. incubation was completed in from 43 to 50 days.

TABLE LXVII.—*Preoviposition, incubation, and larval longevity of Amblyomma cajennense.*

Date engorged female dropped.	Eggs deposited.	Hatching began.	Minimum incubation period.	All larvæ dead.	Larval longevity.	Temperature during incubation.			
						Maximum.	Minimum.	Average daily mean.	Total effective.
1908.	1908.	1908.	*Days.*	1909.	*Days.*	°*F.*	°*F.*	°*F.*	°*F.*
Mar. 23	Apr. 14	June 8	56			90	47	74.15	1,745
Mar. 30	Apr. 15	June 9	56	Apr. 22–May 7	317–332	90	47	74.36	1,756
	Apr. 22	June 12	52	Nov. 9–16, 1908	150–157	90	47	74.66	1,647
	Apr. 24	June 13	51	Apr. 16–May 7	307–328	91.5	47	74.89	1,627
	May 8	June 19	43	Jan. 13–22	208–217	91.5	63	78.57	1,520
	May 13	June 21	40	June 8–16	352–360	91.5	65	78.89	1,436
	May 15	June 22	39	June 9–24	352–367	91.5	67	79.35	1,418
	May 20	June 26	38	Before June 25	364–	91.5	68	80.04	1,408
	May 22	June 27	37	June 25–July 13	363–381	91.5	68	80.11	1,373
	Aug. 26–28.	Oct. 9	45	Apr. 16	189	97.5	51	78.15	1,581
	1909.	1909.		1910.					
	Aug. 29-30.	Oct. 21	54	Feb. 10–24	112–136	97.5	51	76,75	1,823
	May 18	June 29	43	May 20–July 16	325–382	100	47	90.53	1,897

The following are at outdoor temperature:

1908.	1908.	1908.		1909.					
Apr. 22	May 9	July 1	54	June 30	364	91	63	79	1,944
Apr. 22	May 9	July 1	54	July 4	368	91	63	79	1,944
Apr. 22	May 9	June 30	53	June 15	350	91	63	78.98	1,907
Apr. 22	May 9	June 30	53	June 18	353	91	63	78.98	1,907
Apr. 22	May 9	June 30	53	Apr. 14	288	91	63	78.98	1,907
		1909.							
Aug. 17	Aug. 28	Jan. 28	154	Mar. 26	57	99	17	66.23	3,422

The larvæ (Tables LXVII, LXVIII).—The greatest longevity of larvæ observed by us was 386 days. These larvæ hatched June 24, 1908, and were kept in a tube on moist sand in the laboratory. As is shown in Table LXVII, the greatest longevity out of doors was 368 days. In many cases we have observed a few larvæ to be alive over a year after the first eggs deposited by the parent had hatched. The minimum period required for engorgement was 3 days, the greatest number dropping on the fourth day. Newstead states that on man engorgement is completed in from 2 to 4 days.

TABLE LXVIII.—*Engorgement of larvæ of Amblyomma cajennense on bovine.*

Date larvæ applied.	Larvæ dropped engorged—days following application.										Total number dropped.
	1	2	3	4	5	6	7	8	9	10	
July 26, 1907	0	0	20	63	9	0	0	0	0	0	92
July 2, 1908	0	0	0	56	40	3	0	0	0	0	99
May 24, 1909	0	0	0	12	17	30	4	0	0	0	63
July 8, 1909	0	0	0	22	22	0	0	0	0	0	44
July 14, 1909	0	0	0	18	64	0	0	0	0	0	82
Sept. 2, 1909	0	0	0	185	77	20	0	0	0	0	282
Feb. 25, 1910	0	0	0	0	8	17	0	0	0	0	25

A few days after dropping the larvæ cluster together, as in *americanum*, and become quiescent. Soon the anterior part of the body becomes light colored, showing that metamorphosis is taking place. The shortest period in which molting took place was (at a mean temperature of 89.8° F.) 10 days. In this instance a total effective temperature of 468° F. was accumulated. All of the larvæ observed were engorged on bovine animals except three lots which were engorged on guinea pigs.

The nymph (Table LXIX).—In order to determine the longevity of nymphs, 20 that molted July 29, 1907, were isolated in a tube. On November 13, 1907, all were alive; on March 15, 1908, 15 remained active; on July 12, 12 were alive, and on July 29, 8 were alive. On September 5, 1908, 5 were still alive, after a period of 1 year and 43 days. Another lot of 40 nymphs which molted from larvæ September 29 to October 5, 1908, contained 1 individual which lived until June 21, 1909, a period of 265 days. In a third lot which became nymphs September 28, 1908, 5 specimens were alive after a period of 269 days.

The shortest period in which engorgement took place was 3 days, the largest number dropping on the fourth and fifth days.

TABLE LXIX.—*Engorgement of nymphs of Amblyomma cajennense.*

Date nymphs applied.	Host.	Nymphs dropped engorged—days following application.											Total number dropped.
		1	2	3	4	5	6	7	8	9	10	13	
Aug. 19, 1907	Bovine	0	0	2	5	3	3	0	0	0	0	0	13
Oct. 9, 1907	do	0	0	0	0	18	2	1	1	0	0	0	22
July 25, 1908	do	0	0	2	12	7	0	0	0	0	0	0	21
June 14, 1909	do	0	0	1	2	6	0	4	1	0	0	0	14
July 7, 1909	do	0	0	0	0	5	0	0	3	0	0	0	8
Aug. 5, 1909	do	0	0	0	29	6	0	1	0	2	0	0	38
Aug. 26, 1909	do	0	0	0	4	2	0	0	0	0	0	0	6
Dec. 15, 1909	Guinea pig	0	0	0	0	0	0	0	0	0	0	1	1
Feb. 25, 1910	Bovine	0	0	0	0	1	2	0	0	0	0	0	3
Apr. 25, 1910	do	0	0	0	4	0	0	0	0	0	0	0	4

In August, 1909, at a mean temperature of 89.5° F., molting commenced as soon as the twelfth day from dropping. The longest time observed to be required for molting was 105 days. During this period the mean temperature was about 53° F. An effective temperature of 558° F. appears to be required for molting.

The adult (Table LXX).—Of 103 individuals, the sex of which was determined at the time of molting, 65, or 63 per cent, were females. The greatest longevity among adults observed by us was about 466 days. This was the record of a single female which, together with 5 males, was kept on moist sand in the laboratory. These specimens molted in September, 1907. The last male died about December 1, 1908, while the female lived until December 25 of that year. One of 6 females which molted May 20–26, 1908, lived between 381 and 392 days. In another instance a male and a female which became adult September 11–13, 1909, died between 340 and 380 days later. The longevity of 7 other lots of ticks observed during 1908–1910 ranged from 133 to 366 days. All were kept in the laboratory and were not fed as adults. The length of life of males and females appears to be about the same.

Mating, so far as known, takes place only on the host. When placed upon a host the males and females attach readily. In one case a female was observed to remain in the bag covering the scrotum 5 days before attaching. However, they usually attach within 24 hours. Several days, and frequently a week or more, of feeding appear to be required before the male goes in search of a mate. In our observations the males have remained mated for only 2 or 3 days, and often a shorter period, before leaving in search of other mates.

The shortest period in which a female engorged was 7 days and the longest 12 days. One male which was placed on the scrotum of a bull July 27, 1909, attached immediately. It was not observed to copulate with the females, but reattached several times. It was still attached on September 29, a period of 64 days after application and 41 days after the last female, put on the host at the same time, had dropped engorged. During the period while this male was attached a second lot of females was applied and had become engorged. When attached the entire length of the hypostome is buried in the flesh, the palpi bending back and touching the anterior part of the scutum.

TABLE LXX.—*Engorgement of females of Amblyomma cajennense on bovine.*

Adults applied.	Date of attachment.	Engorged females dropped—days following attachment.						Total number dropped.
		7	8	9	10	11	12	
Sept. 30, 1907		1			1			2
Mar. 19, 1908						4	1	5
July 5, 1909	July 6–7			1		1		2
July 27, 1909	July 29–Aug. 1		1			1		2
Sept. 18, 1909	Sept. 18–19					2	1	3
Do	Sept. 24	1						1
	Total							15

LIFE CYCLE.

Larvæ may live as long as 386 days. In summer they may engorge in 3 days and molt as soon as 10 days after dropping. A total effective temperature of 468° F. appears to be required for this transformation. Nymphs may live more than 13½ months if they do not find a host; they engorge as soon as 3 days and molt as soon as 12 days after dropping. The nymphal molt requires an accumulation of 558° F. of effective temperature. Adults may live as long as 466 days if they do not find a host; they may engorge as soon as 7 days after attachment, commence ovipositing 9 days later, and deposit as many as 4,789 eggs. The eggs require 1,370° F. of effective temperature for incubation.

ECONOMIC IMPORTANCE.

In this country *cajennense* is of economic importance in the lower Rio Grande Valley of Texas only. In the vicinity of Brownsville it is very abundant at certain seasons of the year and is the source of great annoyance to horses, mules, cattle, and other domestic animals. Stoll (1890) states that in Guatemala the larvæ of this tick hang on the grass in clusters of thousands, and are the source of great annoyance to travelers. The collection of the Bureau of Entomology contains many specimens taken by Schwarz and Barber in Guatemala, upon their bodies. December 5–8, 1909, Schwarz and Bishopp found this species to be very abundant in all stages at Tampico, Mex. All stages were found in great abundance on horses, and in much smaller numbers on mules, donkeys, and cattle. The adults are especially bad pests to these animals. Many people stated that it was necessary to apply kerosene and lard to their horses at frequent intervals to lessen the number of ticks on them. While collecting insects in the vicinity of Tampico, these ticks proved very annoying. At times the trousers of Schwarz and Bishopp were covered with thousands of larvæ, many of which gained access to the skin and attached. Although much fewer in number, the bites of the nymphs and adults were much more troublesome. While the itching was intense, none of the points of attachment became infected and therefore soon healed. In one case a nearly fully engorged larva was found under the knee, which certainly had not been attached more than 36 hours. Hunters and others who have occasion to spend considerable time in the forests complain a great deal of the attacks of this tick. Schwarz and Bishopp heard of one man whose legs were well covered with suppurating sores and who was ill from the attack of these ticks and the wounds produced by scratching. At Victoria, Tamaulipas, Mex., on December 9–10, a much smaller number of ticks were found; no larvæ were seen and horses were only lightly infested.

The Bureau of Entomology has received large numbers of males of this species from the Guinand Brothers of Caracas, Venezuela, with the statement that they are the source of great loss to the cattlemen in that country.

NATURAL CONTROL.

No observations of natural enemies of this species have been made by us. Newstead (1909) records the finding of engorged females in the stomachs of the tinkling grackle (*Quiscalus crassirostris*). He also observed parrot-billed blackbirds picking ticks, probably of this species, from the heads of horses.

ARTIFICIAL CONTROL.

As with *americanum* the large number of hosts which this species has and the long periods which they can live without a host prohibit successful control by pasture rotation. Dipping, mopping, or handpicking must be resorted to when the species becomes a pest. Dipping as often as every 8 days would be required in order to prevent the dropping of engorged adults.

Genus **DERMACENTOR** Koch.

Five of the nine species of the genus Dermacentor which occur in the United States have been studied and are here considered. One species, *Dermacentor venustus*, has also been studied by Ricketts and by Cooley. This latter species is the only member of the genus that has been shown to transmit disease.

Two different types of life history were found to occur in the genus. While 4 of the species studied, namely, *occidentalis*, *parumapertus* var. *marginatus*, *variabilis*, and *venustus* drop to pass both molts off the host, *nitens* does not do so but transforms upon the host. Another species (*Dermacentor albipictus*) which is now being studied has also been found to have this habit. This habit of molting upon the host, as well as the preference shown by *Dermacentor nitens* for the inside of the ears as a place of attachment, where it is considerably protected from bird and other enemies and where it is not readily removed by the host, must be considered as protective adaptations. The adults of all species of this genus which we have studied excrete large amounts of what appears to be undigested blood, while engorging.

THE RABBIT DERMACENTOR.

Dermacentor parumapertus marginatus Banks.

The common name of this tick is taken from the fact that in the adult stage it is found on no other host than the rabbit, while the adults of other species of the genus Dermacentor are very rarely found on that host.

DESCRIPTIVE.

Adult (Pl. XIII, figs. 3–5).—Males from 2.5 by 1.25 mm. to 3 by 1.75 mm. Females, unengorged, 2.5 by 1.5 mm. to 3.75 by 2 mm.; engorged, 10 by 7 by 3.5 mm. to 15.4 by 10.7 by 7.7 mm. The males have interrupted white markings along the lateral borders of the dorsum. The posterior border of the scutum of the females is white, the lateral borders with interrupted white markings. In both sexes the outer surface at the apex of the leg segments is marked with white, in which are usually two dark red punctations. Some specimens from California, Oregon, and Utah have no white visible, while others are nearly as strongly marked as those from New Mexico and Texas.

Nymph (Pl. XIII, fig. 2).—Unengorged, about 1.23 by 0.79 mm.; engorged, 3 by 2.1 by 1.2 mm. to 3.9 by 2.8 by 1.6 mm. Color, unengorged, reddish brown; engorged, dark slate to almost black. Capitulum 0.305 mm. long (from tip of palpi to base of emargination of scutum); scutum 0.524 mm. long by 0.521 mm. wide.

Larva (Pl. XIII, fig. 1).—Unengorged, about 0.686 by 0.433 mm. (alcoholic); engorged, 1.3 by 0.8 by 0.7 mm. to 1.5 by 0.9 by 0.8 mm. Color, unengorged, reddish yellow; engorged, dark slate. Capitulum 0.148 mm. long (from tip of palpi to base of emargination of scutum); scutum 0.260 mm. long by 0.344 mm. wide.

Egg.—Ellipsoidal, yellowish brown, shining, smooth. The average size of 10 measured was 0.65 by 0.47 mm.

HOST RELATIONSHIP.

The host of the type variety is the jack rabbit. The types of the species (*D. parumapertus*) are labeled as taken from man and in a chicken house. No specimens of this variety have been taken on other hosts than jack rabbit and cottontail rabbit. While very few larvæ and nymphs have been collected on rabbits, it would appear from the fact that no specimens have been taken on any other animal that the rabbit is the principal host of those stages. We have engorged larvæ in our rearing experiments on the fox squirrel, guinea pig, and bovine, as well as rabbit, and nymphs have been engorged on the guinea pig and rabbit.

Although a large number of unengorged adults have been collected, very few fully engorged females have been obtained. It would seem that a large number of them are scratched off by the host before becoming replete. The species is found principally in the ears of the host, but it also attaches on the outside of the ears, on the head, on the neck, and sometimes between the toes. Adults collected on rabbits have been found to attach readily to bovine hosts and to engorge to repletion.

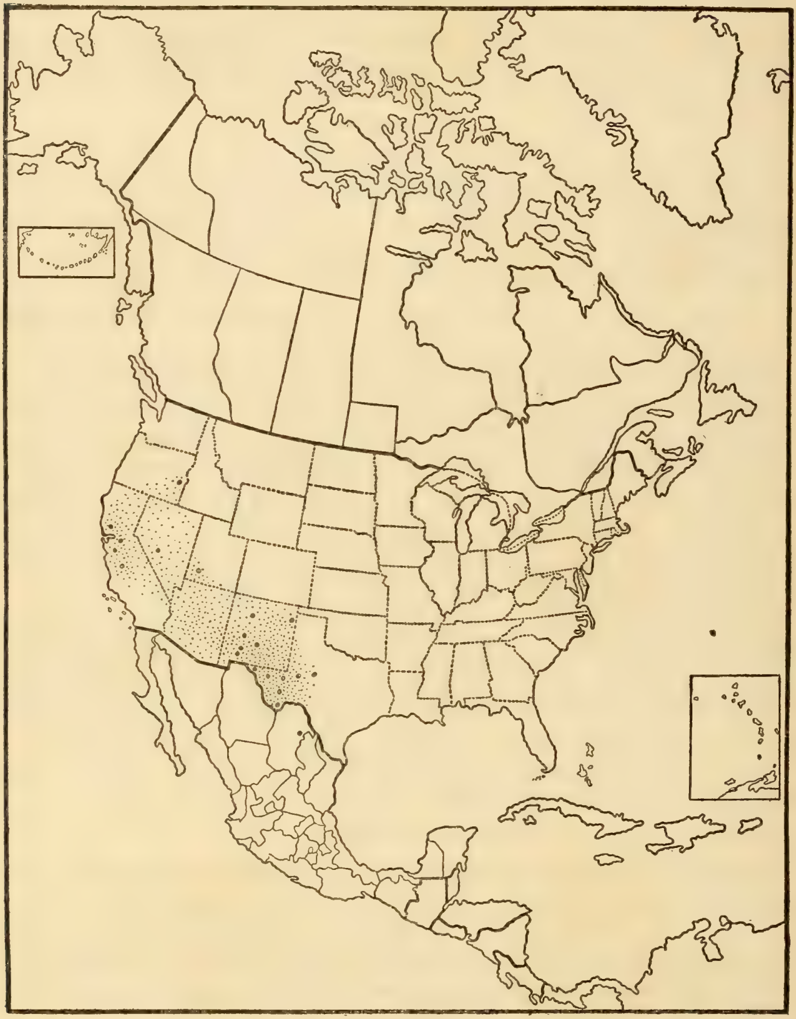
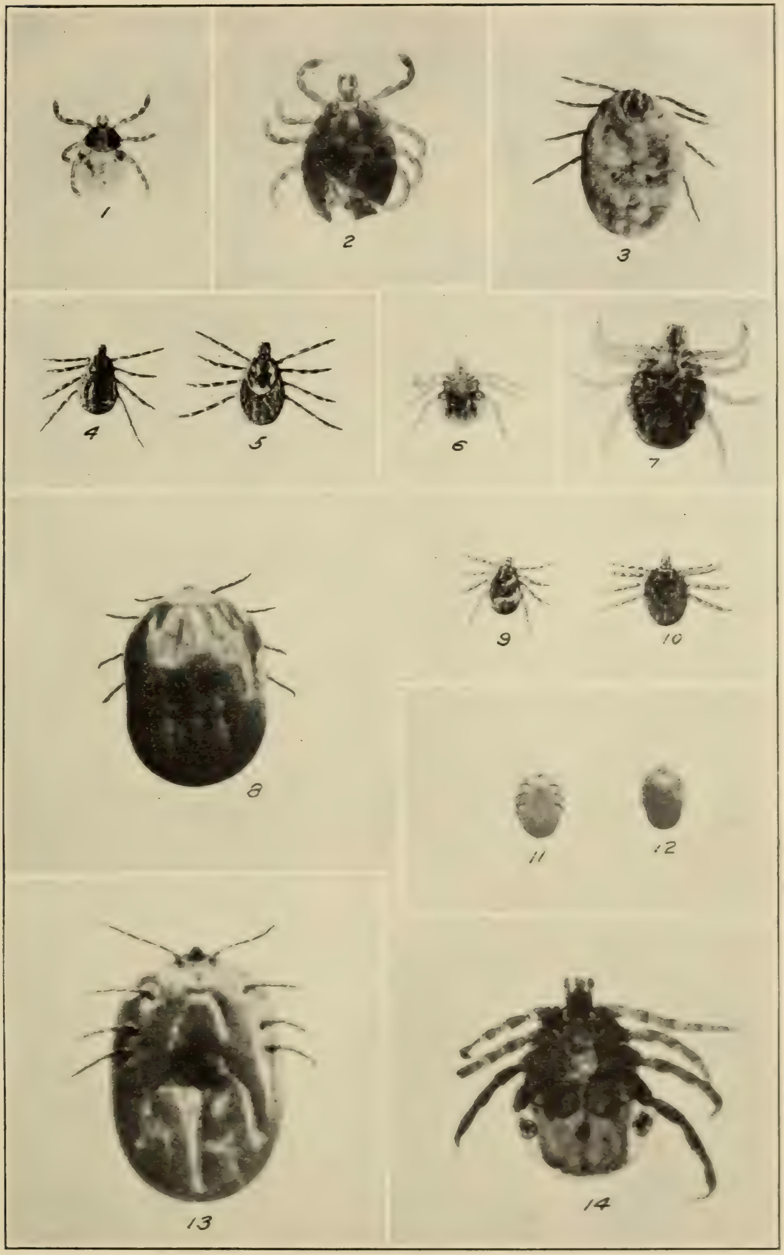


FIG. 13.—The rabbit Dermacentor, *Dermacentor parumapertus marginatus:* Distribution. The large dots show localities where the species has been collected in our investigation. The small dots indicate the probable range of the species in the United States. (Original.)

GEOGRAPHICAL DISTRIBUTION.

(Fig. 13.)

Mesa City, Arizona, is the type locality for this variety. The species is confined to the semiarid and arid west, including Texas west of about the 101st meridian, New Mexico, Arizona, southern Utah, Nevada, California, and southeastern Oregon. It appears to



THE RABBIT DERMACENTOR, DERMACENTOR PARUMAPERTUS MARGINATUS, AND THE TROPICAL HORSE TICK, DERMACENTOR NITENS.

Dermacentor parumapertus marginatus: Fig. 1.—Unengorged larva. Fig. 2.—Unengorged nymph (balsam mount). Fig. 3.—"Deposited-out" female, dorsal view. Fig. 4.—Male, dorsal view. Fig. 5.—Unengorged female, dorsal view. *Dermacentor nitens:* Fig. 6.—Unengorged larva. Fig. 7.—Unengorged nymph (balsam mount). Fig. 8.—Engorged female, dorsal view. Fig. 9. —Male, dorsal view. Fig. 10.—Unengorged female, dorsal view. Fig. 11.—Engorged nymph, ventral view. Fig. 12.—Engorged nymph, dorsal view. Fig. 13.—Engorged female, ventral view. Fig. 14.—Male (balsam mount). (Original.)

be most abundant in western Texas and in New Mexico. Larvæ and nymphs have also been taken at Monclova, Mex.

LIFE HISTORY.

No observations on the biology of this species have been previously published.

The egg (Table LXXI).—In July at a mean temperature of 85° F. oviposition commenced as soon as the fifth day after dropping. Four of 7 ticks which dropped engorged during July and early August commenced oviposition on the fifth day, the three remaining ones commencing a day later. The average oviposition period of 7 females observed in July and August was 15.9 days. The minimum oviposition period was 11 days, within which time 855 eggs were deposited; the maximum, 26 days, during which period 3,247 eggs were laid. The maximum number of eggs recorded for the species is 4,660. The female which made this record deposited 918 eggs during one day. The females died in from 1 to 6 days after deposition was completed. One of the 7 engorged females upon which these counts of eggs were made was collected on a rabbit, while the other 6 females were engorged upon bovines. The measurements of the 6 were as follows: 10 by 7 by 4 mm., 12.5 by 9 by 6.5 mm., 12 by 8.5 by 6 mm., 11 by 7.5 by 4 mm., 10 by 7 by 5 mm., and 10 by 7 by 3.5 mm., respectively.

The shortest incubation period was 20 days, the mean temperature during this period being 85° to 86° F. A total effective temperature of at least 850° F. appears to be required for embryonic development.

TABLE LXXI.—*Incubation and larval longevity of Dermacentor parumapertus marginatus.*

Eggs deposited.	Hatching began.	Minimum incubation period.	All larvæ dead.	Larval longevity.	Temperature during incubation.			
					Maximum.	Minimum.	Average daily mean.	Total effective temperature.
		Days.		*Days.*	*°F.*	*°F.*	*°F.*	*°F.*
June 30, 1908	July 23, 1908	24	....	....	95	70.0	81.1	954.25
July 2, 1908	July 24, 1908	23	....	....	95	70.0	83.1	959.75
July 18, 1908	Aug. 8, 1908	22	Jan. 25, 1909	170	99	76.5	85.5	935.75
July 20, 1908	Aug. 10, 1908	22	Nov. 30, 1908	102	99	73.0	85.4	916.75
July 22, 1908	Aug. 12, 1908	22	Mar. 6, 1909	223	99	73.0	85.7	922.75
July 24, 1908	Aug. 14, 1908	22	Mar. 12, 1909	227	99	73.0	85.9	944.75
July 26, 1908	.....do.......	20	Feb. 10, 1909	197	99	73.0	86.2	868.75
July 27, 1908	Aug. 16, 1908	21	Oct. 26, 1908	71	99	73.0	86.3	909.00
July 28, 1908	Aug. 17, 1908	21	Feb. 15, 1909	227	99	73.0	86.4	911.50
July 30, 1908	Aug. 19, 1908	21	Mar. 12, 1909	222	99	73.0	86.7	917.25
Aug. 3, 1908	Aug. 22, 1908	20	Dec. 6, 1908	106	99	73.0	86.2	863.50
Aug. 5, 1908	Aug. 24, 1908	20	Mar. 9, 1909	214	99	73.0	85.1	857.25
Aug. 8, 1908	Aug. 28, 1908	21	Feb. 17, 1909	167	96	73.0	84.9	878.25
Aug. 14, 1908	Sept. 4, 1908	22	Feb. 5, 1909	144	96	75.0	83.4	908.50
Aug. 16, 1909	Sept. 8, 1909	24	Mar. 30–Apr. 27, 1910	193–221	110	77.0	89.38	1,112.75
Aug. 14, 1909	Sept. 3, 1909	21	Nov. 18, 1909–Jan. 25, 1910	76–144	110	77.0	89.51	976.25

The larva (Tables LXXI-LXXIII).—The greatest longevity of larvæ observed by us was 227 days. Engorgement has taken place as soon as the fourth day. As is shown in the last record in Table LXXII, the longest period of engorgement observed was 14 days. In this case the larvæ were scratched off when between one-fourth and five-sixths engorged. Six of the 8 were engorged sufficiently to molt. The first lot recorded in the table did not attach readily and for this reason those ticks which did not take hold at first were allowed to remain in the bag. Thus the larvæ which dropped on the ninth day probably did not attach until the third day after application. In the third lot recorded in the table the squirrel escaped from the cage on the afternoon of the fifth day after the ticks were applied and was not put back until the next morning. There is little doubt that some larvæ dropped in the meantime.

TABLE LXXII.—*Engorgement of larvæ of Dermacentor parumapertus marginatus.*

Date larvæ applied.	Host.	Larvæ dropped engorged—days following application.											Total number dropped.
		1	2	3	4	5	6	7	8	9	10	14	
Aug. 7, 1908	Bovine	0	0	0	0	0	4	5	3	1	0	0	13
Aug. 26, 1908	do	0	0	0	0	7	2	0	0	0	0	0	9
Oct. 9, 1909	Squirrel	0	0	0	12	5	4	2	0	0	0	0	23
Nov. 4, 1909	Guinea pig	0	0	0	0	2	2	8	7	1	0	0	20
Mar. 11, 1910	do	0	0	0	0	0	2	0	2	0	2	0	6
Sept. 28, 1910	do	0	0	0	0	0	0	0	0	0	0	8	8

At a mean temperature of 87° F. molting occurred on the eighth day, an effective temperature of 350° F. having accumulated.

TABLE LXXIII.—*Molting of engorged larvæ of Dermacentor parumapertus marginatus.*

Date engorged larvæ dropped.	Host.	Number.	Engorged larvæ molted—days following dropping.																	Total number molted.	Temperature from dropping to date first tick molted.		
			8	9	10	11	12	13	14	15	16	19	20	21	23	24	26	39	47		Maximum.	Minimum.	Average daily mean.
1908.																					°F.	°F.	°F.
Aug. 12	Bovine	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	96	76	85.6
Aug. 13	do	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	96	77	86.8
Aug. 14	do	5	0	0	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	5	96	76.5	85.3
Aug. 15	do	3	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	96	76	84.8
Aug. 16	do	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	96	76	84.5
Aug. 31	do	2+	0	2	Others missing.														0	2	97.5	75	85.0
1909.																							
Oct. 13	Squirrel	12	0	0	0	0	0	0	0	4	8	0	0	0	0	0	0	0	0	12	87	51	67.83
Oct. 14	do	5	0	0	0	0	0	1	1	2	1	0	0	0	0	0	0	0	0	5	87	51	71.37
Oct. 15	do	5	0	0	0	0	1	0	0	2	1	0	0	0	0	0	0	0	0	4	87	51	70.92
Oct. 16	do	2	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	86	51	70.93
Nov 9	Guinea pig	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	79	41	64.95
Nov. 10	do	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	79	41	64.75
Nov. 11	do	5	0	0	0	0	0	0	0	0	0	0	0	0	0	2	3	0	0	5	79	34.5	63.55
Nov. 12	do	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	79	20	54.45
Nov. 13	do	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	2	79	32	61.35
1910.																							
Mar. 17	do	2	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	92	53	68.54
Mar. 19	do	2	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	2	92	53	71.82
Oct. 12	do	8	0	0	0	0	0	0	0	1	0	0	0	6	0	0	0	0	0	7	94	43.5	71.58
	Total	68+	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	57	....	....	.....

The nymph (Table LXXIV).—The greatest longevity of nymphs observed by us was 175 days. This record was made on a lot of 7 nymphs which molted from larvæ October 27–31, 1910, and were kept on moist sand in the laboratory. In another lot of 22 nymphs which molted from larvæ October 27 to November 5, 1909, 2 were alive March 9, 1910, when they were put on a host, thus having lived at least 144 days. Three lots of unengorged or slightly engorged nymphs collected on rabbits lived from 30 to 100 days.

Attempts to get nymphs to attach to a bovine failed and in our early experiments no attachments were secured when the nymphs were put on tame rabbits and guinea pigs. In 1910, two attempts to attach nymphs to a fox squirrel failed, and similar results were experienced in two of six tests on guinea pigs. In one instance a single nymph attached readily to a guinea pig, and 2 nymphs put on a rabbit attached and engorged readily.

The shortest period of engorgement observed was 4 days and the longest 25 days.

TABLE LXXIV.—*Engorgement of nymphs of Dermacentor parumapertus marginatus.*

Date nymphs applied.	Host.	Number.	Nymphs dropped engorged—days following application.							Total number dropped.
			4	8	9	10	12	19	25	
Dec. 10, 1909	Guinea pig	9	0	1	0	1	1	1	0	4
Feb. 3, 1910	do	1	0	0	0	0	0	0	1	1
May 25, 1910	Rabbit	2	1	0	1	0	0	0	0	2

Nymphs which dropped in August molted in 21 days when the mean temperature was 88.25° F. One nymph which dropped December 19, 1909, molted 123 days later. This was the longest molting period observed. During this period the mean temperature was 60.24° F. The mean temperature has a decided effect on the length of the molting period. The molting periods of those nymphs which become males and those which become females are about the same. A total effective temperature of 641° F. appears to be required to produce this molt.

The adult (Table LXXV).—The number of individuals of each sex was practically the same in the adults which we observed to molt from nymphs. The greatest longevity recorded occurred in a lot of 11 males and 4 females which were collected on rabbits on April 21–25, 1910. On August 18, 1910, a male and a female were alive, but these died before September 26, 1910, having lived between 115 and 158 days. Of a lot containing 21 males and 8 females which molted between May 12 and May 30, 1910, 2 males and 2 females lived between 80 and 137 days. A number of other lots of collected individuals lived from 25 to 72 days. The longevity of the sexes is practically the same.

Unengorged or slightly engorged males and females taken from rabbits have readily attached when placed upon a bovine host.

They have been found to mate within a day or two and to continue in this relation for a number of days or until the females dropped. As many as three-fourths of the individuals collected in western Texas were found paired. In one instance a male was found paired with a female of *Dermacentor variabilis*. After the dropping of the female with which it had mated, one male was observed mated with a female of *M. annulatus*. It remained in this relation until it was removed from the host a week later.

About 30 lots of this species have been collected by agents of the bureau. In only two instances were any engorged females found. Engorgement of females that were removed from rabbits took place upon bovine hosts in 12 days. A female which was placed upon a tame rabbit with a male on May 25, 1910, did not show any sign of engorging until 10 days later, when it was observed in copulation. Engorgement began on the third day following mating, but the date of dropping of this individual was not recorded. The females, during engorgement, excrete large quantities of material which when dry resembles coagulated blood. This frequently incrusts the male which is beneath the female, thus rendering him helpless and sometimes actually killing him.

The ear of the rabbit, both inside and outside, appears to be preferred as a place for attachment. The large number of males that have been taken from rabbits is sufficient evidence that they remain upon the host for a long period after the females have dropped.

TABLE LXXV.—*Engorgement of females of Dermacentor parumapertus marginatus.*

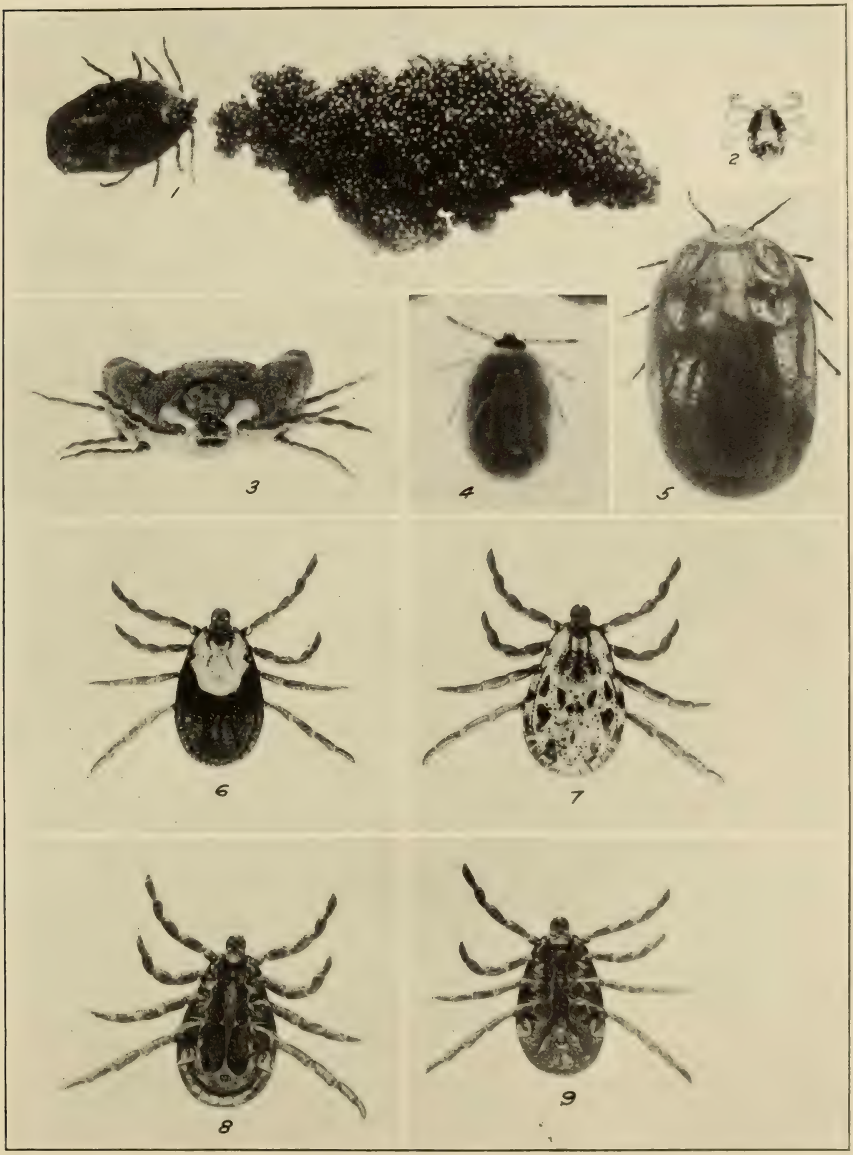
Adults applied.	Host.	Females dropped engorged.	Period of attachment. *Days.*	Size engorged.
June 8, 1908	Bovine	June 21, 1908	13	10 by 7 by 4 mm.
June 29, 1908	do	July 11, 1908	12	11 by 8.5 by 5 mm.
Do	do	July 14, 1908	15	12.5 by 9 by 6.5 mm.
July 7, 1908	do	July 19, 1908	12	12 by 8.5 by 6 mm.
Do	do	July 21, 1908	14	11 by 7.5 by 4 mm.
Do	do	July 25, 1908	18	10 by 7 by 5 mm.
Do	do	Aug. 2, 1908	26	10 by 7 by 3.5 mm.
Aug. 27, 1908	do	Sept. 5, 1908	(Sloughed off.) 9	10 by 7 by 4.5 mm.
June 25, 1909	do	July 7, 1909	12	

LIFE CYCLE.

Larvæ may live as long as 227 days; they engorge as soon as 4 days after application and may molt in 8 days after dropping, a total effective temperature of 350° F. being required.

Nymphs may live as long as 175 days; they may engorge in 4 days after application and molt as soon as 21 days after dropping, a total effective temperature of 641° F. being required.

Adults have been found to live for more than 115 days. Mating takes place on the host. Females may engorge as soon as 12 days after being put on a host; they may begin oviposition as soon as 5 days after dropping and deposit as many as 4,660 eggs. Deposition may continue for 26 days. Embryonic development may be com-



THE ROCKY MOUNTAIN SPOTTED-FEVER TICK, DERMACENTOR VENUSTUS.

Fig. 1.—"Deposited-out" female with eggs. Fig. 2.—Unengorged larva. Fig. 3.—"Deposited-out" female, frontal view. Fig. 4.—Engorged larva. Fig. 5.—Engorged female, dorsal view. Fig. 6.—Unengorged female, dorsal view. Fig. 7.—Male, dorsal view. Fig. 8.—Male, ventral view. Fig. 9.—Unengorged female, ventral view. (Original.)

pleted in 20 days, a total effective temperature of 850° F. or more being required.

ECONOMIC IMPORTANCE.

This variety of *Dermacentor parumapertus* has not been taken on any other host than the rabbit; hence it is of no importance economically.

NATURAL CONTROL.

Rabbits kept in cages have been observed to scratch off and devour fully engorged females. It seems probable therefore that some of these ticks suffer the same fate in nature.

To test the effect of heat upon eggs of this species, a bunch of freshly deposited eggs was placed on the ground in the sun from 3.55 p. m. until sunset. When the eggs were put out the atmospheric temperature was 110° F. and the soil surface temperature was 133° F. The eggs were somewhat shriveled when taken in and later they dried up completely. They showed no sign of embryonic development, while a check lot hatched in 9 days. There is little doubt that heat and dryness are important in controlling the abundance of this species.

One of two nymphs collected on a rabbit at Green Valley, Cal., on June 11,1909, was found to be parasitized by *Hunterellus hookeri*. This is the same species which acts as a parasite of the nymphs of *Rhipicephalus sanguineus*.

THE ROCKY MOUNTAIN SPOTTED-FEVER TICK.

Dermacentor venustus Banks.

The common name of this species is taken from the fact that it is the transmitter of the disease of man known as Rocky Mountain spotted fever.

DESCRIPTIVE.

Adult (Pl. XIV, figs. 1, 3, 5–9).—Males from 2.1 by 1.5 mm. to 6 by 3.7 by 1.4 mm. Females, unengorged, from 3.1 by 1.8 mm. to 5.1 by 3 mm.; engorged, from 13.8 by 10 by 6.4 mm. to 16.5 by 11.4 by 6.9 mm. Male reddish brown; scutum with an extensive pattern of white lines; usually but little white on the middle posterior region; legs slightly lighter than scutum; joints tipped with white; female with scutum mostly covered with white; abdomen reddish brown; legs as in the male.

Nymph.—Unengorged, from 1.36 by 0.72 mm. to 1.54 by 0.8 mm.; engorged, from 3 by 2.1 by 1.3 mm. to 4.8 by 3.3 by 2 mm. Color, unengorged, reddish brown; engorged, dark bluish gray. Capitulum 0.336 mm. long (from tip of palpi to base of emargination of scutum); scutum 0.550 mm. long by 0.554 mm. wide.

Larva (Pl. XIV, figs. 2, 4).—Unengorged, from 0.631 by 0.387 mm. to 0.703 by 0.445 mm.; engorged, from 1.28 by 0.76 mm. to 1.43 by 0.85 mm. Color, unengorged, yellowish brown; scutum darker toward posterior end; engorged, slate-blue. Capitulum 0.139 mm.

long (from tip of palpi to base of emargination of scutum); scutum 0.241 mm. long by 0.350 mm. wide.

Egg.—The average size of 10 eggs measured was 0.645 by 0.460 mm.; light brown, shining, smooth.

HOST RELATIONSHIP.

The host of the type of this species is not known. Most of the information herein presented regarding the host relationship of the species was obtained in the Bitter Root Valley of Montana. The work there was conducted under the general supervision of Mr. W. D. Hunter, but under the immediate direction of Prof. R. A. Cooley. Mr. W. V. King, of the Bureau of Entomology, and Mr. C. Birdseye, of the Bureau of Biological Survey, spent the spring and summer, and Mr. A. H. Howell, of the Biological Survey, a portion of the spring of 1910 in the center of the area where Rocky Mountain spotted fever occurs in its most virulent form. Messrs. King and Birdseye continued this investigation throughout 1911 in the same locality. To these men, who exposed themselves to the dangers of infection in order to collect information regarding this tick and its hosts, we are greatly indebted. In order to identify with certainty the species of ticks collected, the immature stages were sent to the laboratory at Dallas, Tex., and reared to adult and determined. It has been found that practically all of the small mammals act as hosts for the larvæ and nymphs, while the adult stages are seldom found on other than the large domestic animals. Horses and cattle appear to be by far the preferred hosts. Among other domestic animals upon which adults have been found are sheep, mule, ass, dog, hog, goat, and cat (probably unattached). The principal wild mammals found to act as hosts for this stage are the mountain goat, brown bear, coyote, woodchuck, rabbit, wild cat, and badger. The last three appear to be rarely attacked by the adults of this species. The immature stages have been taken on the following hosts which are arranged approximately according to their relative importance: Ground squirrel (*Citellus columbianus*), pine squirrel (*Sciurus hudsonicus richardsoni*), chipmunks (*Eutamias luteiventris, Eutamias quadrivittatus umbrinus*), rock squirrel (*Callospermophilus lateralis cinerascens*), woodchuck (*Marmota flaviventer*), rabbits (*Sylvilagus nuttalli* and *Lepus bairdi*), wood rat (*Neotoma cinerea*), gray meadow mouse (*Microtus nanus canescens*), pika (*Ochotona princeps*), white-footed mouse (*Peromyscus maniculatus artemisiæ*), large meadow mouse (*Microtus modestus*), jumping mouse (*Zapus princeps*), and pocket gopher (*Thomomys fuscus*).

Dr. H. T. Ricketts and Prof. R. A. Cooley have given a considerable amount of information on the host relationship of this species. Dr. Ricketts states that in Idaho this tick was found on the snowshoe rabbit (*Lepus bairdi*) in considerable numbers in all stages of development. It seems very probable, in the light of our recent investigation, that this note applies to the rabbit tick, *Hæmaphysalis leporis-palustris*. Additional information on the host relationships of this species is given by Hunter and Bishopp (1911b).

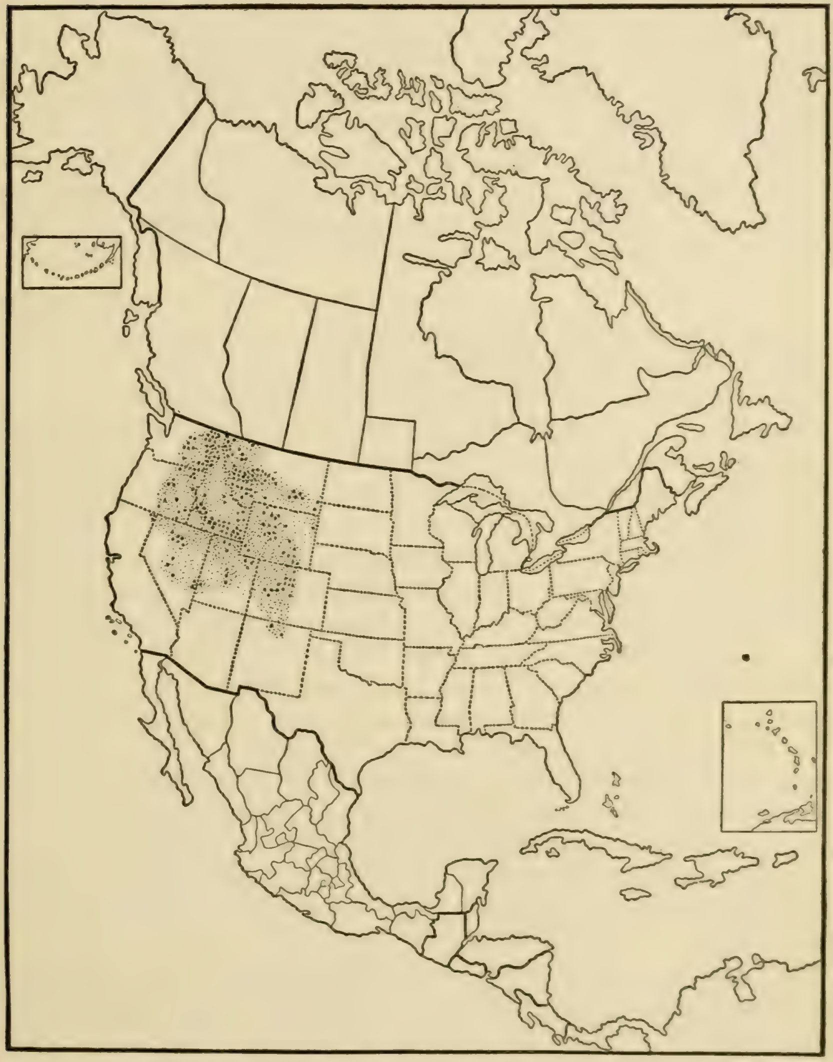


FIG. 14.—The Rocky Mountain spotted-fever tick, *Dermacentor venustus:* Distribution in the United States. The large dots show localities where the species has been collected in our investigation. The small dots indicate the probable range of the tick. (Original.)

We have been able to engorge all the stages of the Rocky Mountain spotted-fever tick on the guinea pig, tame rabbit, and bovine, and the adults have been engorged on the goat.

GEOGRAPHICAL DISTRIBUTION.

(Fig. 14.)

The type locality of this species is Soldier, Idaho. The distribution of this tick has been rather accurately determined by the Bureau of Entomology working in cooperation with Prof. R. A. Cooley and numerous correspondents throughout the Western States. The tick has been found to occur from British Columbia southward to northern New Mexico and from the foothills of the Rocky Mountains in Colorado to the base of the Cascade Range in Oregon and California. It is very abundant in western Montana, and throughout Idaho, eastern Washington, and Oregon, northern Utah, western Wyoming, and northwestern Colorado. A detailed statement regarding the distribution of this species has been published (Bishopp, 1911a).

LIFE HISTORY.

Observations on the biology of this tick have been published by Ricketts (1906, 1907, 1908) and by Cooley (1909, 1911).

The egg (Table LXXVI).—The preoviposition period of this species varies from 5 to 17 days. One partially engorged female which was picked from a host March 24, 1910, had a preoviposition period of 25 days. The temperature experienced by these ticks can not be given accurately, as the ticks were collected in Montana and mailed to the laboratory at Dallas. Females which dropped from hosts at the Dallas laboratory showed a variation of from 6 to 14 days in their preoviposition periods. The shorter period was recorded on specimens kept at 66° F. and the longer on specimens kept at 79° F. However, preoviposition periods of 7 days were observed when the mean temperature was about 80° F. and when the mean temperature was 68° F. preoviposition periods as long as 14 days were observed. The period of deposition varied from 15 to 32 days. The maximum number of eggs deposited by a female was 7,396; the average of 11 was 5,421.8. The individual which deposited the maximum number of eggs measured 16 by 11.5 by 6.1 mm. before deposition was begun. The number of eggs deposited by an individual is governed largely by its size.

Females which were removed from a host when about one-fourth engorged have been found to deposit fertile eggs. Three females which measured 8 by 5.5 by 2 mm., 8.3 by 5.3 by 2 mm., and 8.5 by 5.5 by 2 mm., began depositing on the fourteenth, tenth, and twelfth days after being removed from the host and deposited 211, 1,019, and 636 eggs, respectively.

The minimum incubation period recorded was 16 days. This occurred in the case of eggs deposited June 13, 1908, which experienced a mean temperature of 81.4° F. A total effective temperature of 614.75° F. was accumulated during this period. Ricketts states (1909a, p. 100) that in Montana eggs deposited in July hatch in from

30 to 50 days after they are deposited. Records made by Mr. W. V. King show the incubation period to vary from 34 to 51 days in the Bitter Root Valley in Montana.

TABLE LXXVI.—*Preoviposition, incubation, and larval longevity of Dermacentor venustus.*

Date engorged female dropped.	Deposition began.	Pre-oviposition period.	Hatching began.	Minimum incubation period.	All larvæ dead.	Larval longevity.	Temperature during incubation.			
							Maximum.	Minimum.	Average daily mean.	Total effective temperature.
1908.	1908.	*Days.*	1908.	*Days.*			° *F.*	° *F.*	° *F.*	° *F.*
	June 6......	......	June 24........	19	....	....	91.5	69	80.8	718.25
	June 7......	......	.....do........	18	....	....	91.5	69	80.8	680.5
	June 13......	......	June 28........	16	....	....	91.5	71	81.4	614.75
	June 15......	......	July 1........	17	....	....	90	71	80.8	641.75
1909.	1909.		1909.							
[1] July 1	Before July 14.	13	July 31........	18+	Before Sept. 15.	46–	....	....	......	....
[1] June 11	June 27......	16	July 15........	19	Aug. 26–Sept. 15.	42–62	102	47	91.8	917
1910.	1910.		1910.							
[1] Mar. 28	Apr. 7.......	10	May 10........	34	July 19–Aug. 5.	70–87	91	43	70.49	744.66
Apr. 7	Apr. 17......	10	May 19........	33	Before July 19.	61–	95	51	74.6	979.6
Apr. 12	Apr. 18......	6	.....do........	32	July 19–Aug. 5.	61–78	91	43	70.33	874.56
Do....	Apr. 22......	10	May 25........	34	Aug. 8........	75	91	43	74.8	1.081.2
[1] Apr. 13	Apr. 20......	7	.....do........	36	Aug. 5–20....	72–87	91	43	71.78	1.036.08
Apr. 26	May 2.......	6	May 31........	30	July 20–Aug. 5.	50–66	91	59	71.66	859.8
[1] May 1	May 10......	9	June 6........	28	July 21–Aug. 5.	45–60	100	59	77.02	952.56
[1] May 14	May 23......	9	June 12........	21	Aug. 25–31....	74–80	100	60	79.64	769.44
[1] June 4	June 13......	9	June 29........	17	Sept. 29.......	92	97	69	84.37	703.29
[1] June 8	.....do......	5	July 1........	19	Aug. 25–31...	55–61	97	69	84.59	790.21
[1] July 16	July 25......	9	Before Aug. 10.	17–	Sept. 24–Oct. 5.	45–56	104	79	90.19	755.23
1911.	1911.		1911.							
Mar. 27	Apr. 4.......	8	May 14........	41	....	....	89	52	71.7	1,176.7

[1] This tick was picked from the host.

The larva (Tables LXXVI–LXXVIII).—The longest time between the beginning of hatching of a lot of eggs deposited by a single female and the death of the last larva was 92 days. In this case the eggs and larvæ were kept on moist sand in a tube in the laboratory. Hatching began on June 29, 1910, and the last larva died on September 29. In the majority of cases in a series of over 200 observations the last larva died within 85 days from the time the first eggs in the lot hatched. In a number of lots of eggs separated from the parent female the day they were deposited the larvæ all died within 2 months after hatching, even though kept under the most favorable conditions. In a number of instances larvæ which hatched the latter part of July and early in August all died within a month. Cooley's experiments in Montana (1909, p. 102), as well as tests made by W. V. King in that State, indicate that the longevity of larvæ in Montana is about the same as that observed by us at Dallas, Tex.

On account of the fact that the period of deposition is frequently longer than the incubation period, in warm weather the larvæ begin to hatch from the first eggs deposited some time before deposition is complete.

Ordinarily larvæ attach within a very short time after they are applied to a host. However, we have observed them to remain unattached for three days when kept in close proximity to a host. The majority of the larvæ attach around the head and ears of the hosts. They are, however, frequently found on the back, especially between the shoulders. Larvæ when removed from a host when slightly engorged were found to attach to another host several days or even weeks later.

In a number of instances larvæ which had awaited a host for two months were found to attach when placed on a host, but many, and in some cases all, died without engorging owing to their weakened condition.

The shortest period required for the engorgement of larvæ was two days. The greatest number drop from the host on the third, fourth, and fifth days after attachment. In two cases larvæ remained on the host for 8 days.

TABLE LXXVII.—*Engorgement of larvæ of Dermacentor venustus.*

Date larvæ applied.	Host.	Larvæ dropped engorged—days following application.								Total number dropped.
		1	2	3	4	5	6	7	8	
1908.										
March 30	Bovine	0	0	0	1	2	0	0	0	3
April 2	do	0	0	23	27	17	13	3	1	84
May 13	do	0	0	0	15	10	0	0	0	25
July 8	do	0	0	2	3	0	0	0	0	5
July 12	do	0	0	76	64	12	4	0	0	156
1909.										
July 28	Guinea pig	0	0	0	0	6	2	2	0	10
July 30	do	0	0	0	0	6	5	0	0	11
Do	Bovine	0	0	0	2	1	0	0	0	3
Aug. 2	Rabbit	0	0	0	0	3	0	0	0	3
Aug. 4	Guinea pig	0	0	0	0	2	0	0	0	2
Do	Bovine	0	0	0	1	2	0	0	0	3
Aug. 17	do	0	0	0	1	0	0	0	0	1
Do	Guinea pig	0	0	0	0	0	1	0	0	1
Aug. 25	do	0	0	0	0	23	23	2	0	48
Aug. 27	do	0	13	26	58	56	23	5	0	181

When the mean temperature was about 83° F. larvæ were found to become quiescent in from 24 to 60 hours after dropping. Immediately after becoming quiescent the tick begins to take on a light color at the anterior end.

Larvæ which dropped September 1, 1909, began molting on the sixth day thereafter. This was the shortest molting period observed. The mean temperature during the period was 88.29° F. and a total effective temperature of 272° F. was accumulated. The longest period from dropping to molting observed by us was 19 days. The mean temperature during this period was 70.5° F. The effect of temperature on the length of the molting period is marked. When the mean temperature was about 70° F. molting began between the thirteenth and sixteenth days; when the mean temperature was about 77° F. molting began between the eighth and tenth days, and when the temperature was about 88° F. molting began between the sixth and eighth days. Cooley reports (1909, p. 101) that larvæ which dropped during the latter part of July at indoor temperature at Bozeman, Mont., commenced to molt in as soon as 13 days thereafter, and that the majority molted within three weeks. We have found that larvæ will often molt if removed from the host when only slightly over one-half engorged. The molting period of specimens which are not fully engorged is noticeably longer than in replete individuals.

The last six lots, the molting of which is recorded in the accompanying table, contained individuals from one-half to almost fully engorged. The length of the molting period was undoubtedly lengthened on account of the ticks having been picked from hosts before they were replete. The temperatures given with these lots are those recorded at the Dallas laboratory from the time the ticks were collected in Montana until molting began. The specimens undoubtedly experienced lower temperatures than those recorded during the few days prior to their receipt at Dallas.

TABLE LXXVIII.—*Molting of engorged larvæ of Dermacentor venustus.*

Date engorged larvæ dropped.	Host.	Number.	Engorged larvæ molted—days following dropping.														Total number molted.	Temperature from dropping to date first tick molted.		
			6	7	8	9	10	11	12	13	14	15	16	17	18	19		Maximum.	Minimum.	Average daily mean.
1908.																		°F.	°F.	°F.
Apr. 4	Bovine	3	0	0	0	0	0	0	0	0	0	0	1	1	0	0	2	85	54	70
Apr. 5	do	23	0	0	0	0	0	0	0	0	0	2	2	7	2	1	14	85	58	70.5
Apr. 6	do	27	0	0	0	0	0	0	0	1	5	11	6	2	0	0	25	85	58	70.4
Apr. 7	do	17	0	0	0	0	0	0	0	1	7	2	2	2	1	0	15	85	58	70.3
Apr. 8	do	13	0	0	0	0	0	0	0	0	5	8	0	0	0	0	13	80	58	70.3
May 17	do	15	0	0	0	0	1	9	2	1	0	0	0	0	0	0	13	87	68	77.4
May 18	do	10	0	0	0	1	6	3	0	0	0	0	0	0	0	0	10	87	68	77.6
July 15	do	76	0	0	0	2	26	31	0	0	0	0	0	0	0	0	59	95	76.5	84.3
July 16	do	43	0	0	4	17	20	2	0	0	0	0	0	0	0	0	43	95	76.5	84.4
July 17	do	9	0	0	0	5	1	1	0	0	0	0	0	0	0	0	7	95	76	83.9
1909.																				
July 19	do	3	0	0	2	0	1	...	...	...	...	...	...	...	...	...	3	97	79.5	89.72
Aug. 2	Guinea pig	6	0	1	1	2	0	1	0	1	0	0	0	0	...	...	6	102	78.5	88.57
Aug. 6	do	7	0	3	0	0	4	...	...	...	...	...	...	...	...	...	7	96	78	85.75
Aug. 29	do	36	0	(1)	22	5	5	1	0	0	0	0	0	0	0	0	33	98	80	88.5
Aug. 30	do	49	(1)	8	21	7	2	0	0	0	0	0	0	0	0	0	38	98	80	88.37
Aug. 31	do	60	0	10	30	12	0	0	0	0	0	0	0	0	0	0	52	98	78.5	88.18
Sept. 1	do	56	2	14	27	5	0	0	0	0	0	0	0	0	0	0	48	98	78.5	88.29
Do	Rabbit	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	98	78.5	88.32
Sept. 2	Guinea pig	25	0	12	8	0	0	0	0	0	0	0	0	0	0	0	20	99	78.5	88.55
1910.																				
July 4[2]	Ground squirrel	17	0	0	0	0	0	1	0	0	0	12	0	1	0	0	14	97	73	85.5
July 14[2]	do	23	0	0	0	0	0	17	0	3	0	0	0	0	0	0	20	103.5	73	88.25
July 22[2]	Chipmunk	20	0	0	0	0	0	0	17	0	0	0	0	0	0	0	17	104	80	90.5
July 29[2]	Ground squirrel	14	0	0	0	0	0	0	0	6	2	6	...	...	...	...	14	104	79	84.48
Aug. 10[2]	Pine squirrel	29	0	0	0	0	7	(1)	11	1	...	...	...	...	...	...	19	104.5	82	92.1
Aug. 14[2]	Wood rat	3	0	0	0	0	0	0	1	1	0	1	...	...	...	...	3	104.5	73	90.69
	Total	586	...	...	...	...	...	...	...	...	...	...	...	...	...	...	496	...	...	...

[1] The larvæ which molted on this day are included with those recorded on the following day.

[2] These ticks were picked from native hosts in Montana and varied from one-half to fully engorged.

The nymph (Tables LXXIX–LXXX).—The greatest nymphal longevity observed by us occurred in the case of a lot of 119 nymphs which molted from larvæ September 5–10, 1909. These nymphs, as also all other lots here recorded, were kept in the laboratory in tubes on moist sand. During the fall months 21 nymphs were removed from this lot and put on hosts, and during March, 1910, 16 were applied to hosts, 10 of these being applied March 18. On April 20, 1910, only one specimen was alive. This individual died before June 3, 1910. Thus it is seen that during the winter months a considerable number of nymphs lived for at least 189 days, at which time they were applied to a host and became engorged, and one nymph lived between 252 and 271 days. It seems certain that had none of this lot been put on hosts, some individuals would have lived considerably longer.[1] In a lot of 12 or more nymphs which molted from larvæ April 19–21, 1908, 3 individuals were alive 178 days later. The last specimen died October 21, 1908, having lived between 183 and 185 days. One individual in a lot of 7 or more specimens which became nymphs July 24–25, 1908, lived between 137 and 145 days. All specimens in two other lots of about 7 individuals each were found to have died between 56 and 75 days after they transformed to nymphs on July 25, 1908.

Among nymphs which were collected from hosts when slightly to one-third engorged, a longevity of from 47 to 122 days was recorded. The longest period—namely, 122 days—was observed in the case of one individual in a lot of 59 unengorged or very slightly engorged nymphs which were collected on a ground squirrel on April 12, 1910, at Florence, Mont., by Mr. W. V. King.

Nymphs kept in tubes in the laboratory at Dallas were found to be active most of the time at all seasons of the year while awaiting hosts. Occasionally a few individuals were seen to be grouped together and remaining quiet. These, however, were readily disturbed.

In most instances nymphs have been found to attach almost immediately after being placed on a host. Individuals have been found to attach to a host and become engorged after having been picked from another host when as much as one-fourth engorged.

Engorged nymphs have dropped as soon as the fourth day following attachment, the last leaving the host on the ninth day. This period is the same as that recorded by Ricketts (1908, p. 101). The engorgement period of nymphs which were collected on hosts when slightly engorged appears to be somewhat shorter than in the case of those nymphs which have not before been attached to a host. In two instances these slightly engorged nymphs have been found to drop fully engorged on the third day after application. The longest period required for engorgement, of these reattached nymphs, was 6 days.

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[1] Since the above was written a record of nymphs living over 300 days has been made by us.

TABLE LXXIX.—*Engorgement of nymphs of Dermacentor venustus.*

Date nymphs applied.	Host.	Number.	Nymphs dropped—days following application.							Total number dropped.
			3	4	5	6	7	8	9	
1908.										
Apr. 1	Bovine	+34		2	17	13	2			34
May 14	do	+16		2	6	3	4	1		16
1909.										
Aug. 9[1]	Rabbit	10	1	5	3					9
Aug. 13	Guinea pig	6		1	1					2
Sept. 10	Rabbit	9		2	5					7
Oct. 5	Bovine	7				1		2		3
1910.										
Mar. 18	Guinea pig	10			2	1	2			5
Apr. 29[1]	Squirrel	10			2	5				7
May 17[1]	Guinea pig	3					2		1	3
May 24	Bovine	8				4				4
July 27	Rabbit	10			7	1				8
Aug. 9[1]	do	9		5	3					8
Aug. 13	do	13			8	2	1			11
Aug. 15[1]	Guinea pig	30	7	12	3					22
Aug. 19	Rabbit	14		5	1				1	7
Aug. 25[1]	Guinea pig	9			4	4				8
	Total	+198								154

[1] These individuals were collected on hosts when unengorged or slightly engorged and reattached on this date.

In our observations engorged nymphs molted in two instances as soon as the eleventh day after dropping. The first instance occurred in a lot of ticks which dropped August 6, 1908. The mean temperature during this period was 87° F., 485° F. of effective temperature having been required for this transformation. Most of the ticks from this same lot, which dropped on the same day, molted on the fourteenth, fifteenth, and sixteenth days. The second case, when a molting period of 11 days was observed, occurred with a nymph which dropped July 21, 1910. The mean temperature during this period was 89.5° F. and the total effective temperature was 511° F. There is a great variation in the periods required by this species for molting. Thus of 3 engorged nymphs which dropped May 20, 1908, 2 molted to females on the seventeenth and eighteenth days, while the third did not molt to adult until the forty-ninth day after dropping. A still more marked variation in the molting periods of a group of ticks was observed in a lot of 3 nymphs which dropped October 3, 1909. Two of these molted on the eighteenth and nineteenth days after dropping, while the third did not transform until March 22, 1910, or 170 days after dropping. Both of these lots were kept under identically the same conditions and all appeared to be fully engorged. In the second instance the molting of the last nymph was undoubtedly delayed by the approach of cold weather, but the first instance, as well as other similar cases of variation in molting periods, are difficult to explain. Cooley (1909, p. 101) found nymphs which dropped August 12 to commence molting in 42 days, while others required 47 days. Ricketts states (1908, p. 102) that the period required for molting varies from 1 to 3 months, according to the temperature.

After dropping, the nymphs remain rather active for from 3 to several days or even weeks, depending upon temperature and state of engorgement. When it is cool the activity continues for a longer period than during hot weather and partial engorgement has the same effect. The nymphs usually become inactive gradually and within a few days after complete quiescence the area around the anterior end and the antero-lateral borders begins to become white. Dr. Ricketts has found the engorged nymphs to remain active in Montana during July and August for from 2 to 4 weeks, while if placed in a refrigerator they remained active for as long as 3 months. The sexes can often be distinguished several days before molting occurs by the appearance of the color pattern of the adult showing through the skin. In one case the female shields were easily seen 6 days before molting took place. Some days prior to molting the surface of the body of the engorged nymphs frequently becomes dotted with small drops of a yellowish transparent fluid exudate.

Molting is accomplished in the same manner as observed in other species of Dermacentor. The old skin first becomes free from the body at the anterior end, then splitting occurs on each side just above the third pair of legs. Later this splitting extends forward on each side to the lateral angles of the scutum, where the splitting follows the edges of the shield and the two fissures meet at the tip of the scutum. In many cases the force exerted by the tick causes the splitting to extend back around the ventro-lateral margin so that the skin is broken in two. In other cases the lateral fissures extend backward along the dorso-lateral border to the second festoon grooves where they follow these grooves toward the venter, the dorsal end of the skin forming a hinge which allows the escape of the tick.

The length of the molting period of nymphs which transform to males and of those which become females is about the same.

TABLE LXXX.—*Molting of engorged nymphs of Dermacentor venustus.*

Date engorged nymphs dropped.	Host.	Number.	Engorged nymphs molted—days following dropping.																		
			11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	29	30	31
1908.																					
May 18	Bovine	2						1♂	1♀												
May 19	.....do	6							1♂	1♂ 1♀											
May 20	.....do	4							1♀	1♀											
May 21	.....do	4							1♂												
Aug. 6	.....do	17	1♀			4♂	3♂ 2♀	4♂ 2♀													
Aug. 7	.....do	13				1♂ 1♀	2♂ 1♀	6♂	1♂												
1909.																					
Aug. 18	Guinea pig	1				1♂															
Sept. 15	Rabbit	5										1♂ 2♀	2♂								
Oct. 3	Bovine	3								1♂	1♂										
1910.																					
Mar. 10	Rabbit	1																			
Mar. 23	Guinea pig	2																			
Apr. 14[1]	Ground squirrel	13																			
May 5	Fox squirrel	5																			
May 16[1]	Ground squirrel	25																	1♀	2♂ 2♀	2♂ 1♀
May 30	Bovine	3													1♂		1♀	1♀			
June 13[1]	Ground squirrel	16												3♂ 2♀	2♂ 5♀	1♂					
July 21	Guinea pig	1	1♂																		
July 26[1]	Ground squirrel	10										1♂ 5♀	1♂ 1♀			1♀					
July 29[1]	Woodchuck	15									1♀	1♂ 2♀	2♀	4♀		1♀					
Aug. 1	Rabbit	6			1♂	1♂ 1♀	2♂														
Aug. 11	Guinea pig	3		2♀		1♂															
Aug. 18	Rabbit	7		1♂			2♀			1♂ 3♀											
Do.	Guinea pig	7			2♂ 2♀	2♀	1♀														
Aug. 19	.....do	12		2♀	2♂ 1♀	3♂ 3♀		1♀													
Aug. 30	.....do	6			1♂ 1♀	1♂ 1♀	1♂	1♂													
Sept. 28	Squirrel	1									1♀										
	Total	188																			

[1] These nymphs were collected on native hosts in Montana when from one-half to fully engorged.

TABLE LXXX.—*Molting of engorged nymphs of Dermacentor venustus*—Continued.

Date engorged nymphs dropped.	Host.	Number.	Engorged nymphs molted—days following dropping.														Number molted.			Temperature from dropping to date first tick molted.		
			32	33	34	35	37	40	41	42	43	46	49	61	71	170	Male.	Female.	Total.	Maximum.	Minimum.	Average daily mean.
1908.																				° F.	° F.	° F.
May 18	Bovine	2															1	1	2	88.5	68.	78.6
May 19	do	6									1♀						2	2	4	88.5	68	79
May 20	do	4											1♀				0	3	3	88.5	68	79.1
May 21	do	4					1♀		1♀								1	2	3	89	68	79.2
Aug. 6	do	17															11	5	16	99	73	87.1
Aug. 7	do	13															10	2	12	99	73	86.5
1909.																						
Aug. 18	Guinea pig	1															1	0	1	103	77	88.52
Sept. 15	Rabbit	5															3	2	5	95.5	56	77.45
Oct. 3	Bovine	3														1♂	3	0	3	92.5	52.5	73.25
1910.																						
Mar. 10	Rabbit	1													1♂		1	0	1	92	43	70.55
Mar. 23	Guinea pig	2								1♀				1♂			1	1	2	89	43	70.80
Apr. 14[1]	Ground squirrel	13						1♀	2♀	1♀	1♂ 2♀	2♂ 2♀					3	8	11	91	43	70.86
May 5	Fox squirrel	5	1♀	1♂	1♂ 1♀												2	2	4	100	59	76.27
May 16[1]	Ground squirrel	25	5♂ 6♀			1♂ 2♀											10	12	22	100	60	81.69
May 30	Bovine	3															1	2	3	100	66	86.98
June 13[1]	Ground squirrel	16															6	7	13	98	69.5	90.63
July 21	Guinea pig	1															1	0	1	104	77.5	89.50
July 26[1]	Ground squirrel	10	1♂														3	7	10	104	79	90.80
July 29[1]	Woodchuck	15															1	10	11	104	79	90.07
Aug. 1	Rabbit	6															4	1	5	103	79	91.27
Aug. 11	Guinea pig	3															1	2	3	104.5	81.5	92.54
Aug. 18	Rabbit	7									1♂						2	5	7	104.5	73	88.96
Do	Guinea pig	7															2	5	7	104.5	73	88.94
Aug. 19	do	12															5	7	12	104.5	73	88.85
Aug. 30	do	6															4	2	6	98	72.5	85.62
Sept. 28	Squirrel	1															0	1	1	91	54.5	77.68
	Total	188															79	89	168			

[1] These nymphs were collected on native hosts in Montana when from one-half to fully engorged.

The adult (Table LXXXI).—Of 355 adults, the sex of which was determined when they molted from nymphs, 172, or 48.5 per cent, were males. Immediately after molting both sexes are rather plump; the voiding of numerous pellets of white excrement begins almost immediately, and within a few days the thickness of the ticks is much reduced. The voiding of excrement continues for some time, but the amount is greatly decreased after the first few days following molting.

Partial feeding in the nymphal stage has a marked effect on the resultant adults. The size is frequently reduced by more than one-half, the color pattern is often very weak or does not appear at all, and certain structures are affected.

The longevity of the adults of this species is remarkably great. One male in a lot which molted to adults in June, 1908, lived between 188 and 197 days. Three lots of ticks which molted between August

22 and August 25, 1908, lived between 250 and 290 days. The greatest longevity among a large number of lots of ticks which became adult during 1909 was between 320 and 353 days. This record was made on a single male which molted between August 30 and September 1, 1909, and died between July 18 and August 18, 1910. The other lots which became adults during 1909 lived between 117 and 321 days. Among over a hundred lots, the molting of which was observed by us during 1910, the longevity ranged between 66 and 367 days. The majority of these lots contained some individuals which lived over 250 days and a considerable number showed a longevity of over a year.

Still more remarkable is the longevity exhibited by lots of adults collected in Montana during the spring of 1910 by Mr. W. V. King, before they had attached to hosts. Among the several lots observed the longevity varied from 55 to 413 days. Four of these lots which were obtained from shrubbery between March 18 and May 31, 1910, lived more than 320 days. The greatest longevity observed occurred in a lot of one male and two females collected at Victor, Mont., April 2, 1910. One female lived until May 20, 1911, or a period of 413 days. It should be borne in mind that these collected individuals undoubtedly came to maturity in the fall of 1909 and passed the winter in hibernation. Therefore we should add about six months to the longevity observed, making a total longevity of about 600 days. It is thus apparent that ticks which become adult in the latter part of the summer may survive until the second spring following. Adults collected from animals during the spring and summer of 1910 were found to live between 40 and 262 days. The females in these lots varied from unengorged to about one-eighth engorged. The length of the life of the sexes appears to be about the same.

All longevity records are based on ticks kept in tubes on moist sand in the laboratory.

There is a marked tendency for adults which are awaiting a host to climb to a considerable height on shrubs or trees so that they are in a position to be brushed off by large animals when passing. When disturbed they either grasp any passing object with the forelegs, or curl the legs up, drop, and catch hold of any object which they happen to strike in falling. When one moves an object near specimens which are awaiting a host, the ticks begin to extend and wave the forelegs, the other legs also being frequently extended. Engorged females also use the legs for feelers in their search for suitable places for concealment In one case an engorged female was observed to extend and wave all of the legs but one, which was used to cling to the inclined surface upon which it was crawling.

Newly molted adults show no desire to attach to hosts. In fact, the habit of attaching to hosts in the spring months only is so firmly fixed in adult ticks of this species that it is very difficult to induce them to attach to hosts at other seasons of the year. We have observed both sexes to remain motionless in tubes in the laboratory for weeks and even months at a time During this resting period the ticks usually keep the legs closely curled up to the body and it is often difficult to induce activity.

About twenty trials were made between September 1 and December 15 to secure the attachment of adults which had matured the preceding spring. Bovines, guinea pigs, and rabbits were used as hosts. In only two instances were any specimens induced to attach and in neither of these cases did engorgement or mating take place. In one of these instances 3 females and 2 males attached when applied to a guinea pig on October 4, 1910. All of the specimens changed their points of attachment a number of times, but no perceptible engorgement took place. One of the females remained on the host until December 22, or 79 days, and the male did not disappear from the host until a few days later. During the early spring months no great difficulty was encountered in getting adults to attach to guinea pigs, rabbits, goats, or bovines.

When placed on a host the adults usually crawl about carefully for some time before attaching. On small mammals they attach to any part of the body, but on large mammals, in nature, we have found them to attach mainly between the legs, along the escutcheon, belly, and dewlap, and sometimes on the shoulders. On horses they frequently attach under the jaws and sometimes in the mane. In one instance a number of males and females were placed on the legs and dewlap of a yearling bull at 4 p. m.; by 5 p. m. a considerable number of them had reached the animal's back and were crawling about there. The next morning all of the specimens that could be found (3 males and 7 females) were attached on a small area on the top of the shoulders.

Mating occurs on the host. We have not observed a male to attach beneath a female before it had fed for at least 4 days. Usually a feeding period of from 6 to 8 days appears to be necessary before the males start in search of mates. The males have been observed to insert their mouthparts in the genital opening of the females immediately after passing beneath them. In one instance, at least, the palpi of the male were not inserted with the hypostome. The act of copulation appears to occupy only a short time, probably less than an hour, then the males attach close to their mates, the ventral surfaces together, and the legs of the males clasping the legs or body of the females. It seems quite certain that copulation takes place more than once while the males remain beneath the females. In a number of instances males have been observed to remain with females until the latter had become engorged and dropped, when they sought other mates. As many as three females have been seen to be fertilized by a single male. In many cases the females are nearly engorged before being visited by a male. Some of our observations indicate that the males usually start in search of mates in the early morning or late in the evening. Males have been observed to remain on a host for two months, at the end of which time they were removed. During this period two successive lots of females were applied and engorged, the males fertilizing both of them.

The period of engorgement at Dallas, Tex., varied from 8 to 17 days. After fertilization takes place engorgement appears in most cases to proceed more rapidly.

TABLE LXXXI.—*Engorgement of adults of Dermacentor venustus.*

Date females applied.	Host.	Number.	Females dropped engorged—days following application.								Total number dropped.
			8	9	10	11	12	13	14	17	
May 15, 1908	Bovine	2	1							1	2
June 15, 1909	do	2							1		1
Mar. 19, 1910	Guinea pig	2		1							1
Mar. 29, 1910	do	1		1							1
Apr. 1, 1910	Bovine	4				2	2				4
Apr. 13, 1910	do	1		1							1
Apr. 15, 1910	Guinea pig	1				1					1
May 4, 1910	Bovine	3	1		1			1			3
July 23, 1910	Rabbit	5							1		1
Mar. 29, 1911	Bovine	14		5	1				1		7

LIFE CYCLE.

The larvæ have a longevity of about 2 months. They engorge in from 2 to 8 days after attaching to a host and may molt as soon as 6 days after dropping, a total effective temperature of 272° F. being required for this molt. Nymphs may live for more than 300 days. They engorge in from 4 to 9 days after attaching to a host and they may molt as soon as the eleventh day after dropping, a total effective temperature of 485° F. being necessary to produce this transformation. Adults have been observed to live for 413 days and since this record was made on ticks which were collected in the spring, they must have had a total longevity of about 600 days. Females may engorge as soon as 8 days after finding a host, commence depositing eggs as soon as the fifth day following dropping, and deposit as many as 7,396 eggs. Embryonic development may be completed in 16 days, an effective temperature of 614° F. being required.

It appears that the life cycle of this tick usually requires 2 years. The winter is spent in the unengorged nymphal and the unengorged adult stages. The adults begin to emerge from hibernation soon after the snow disappears. The great majority of them attach to the large mammals between March 10 and June 10, then engorge and deposit eggs from which larvæ hatch. These larvæ engorge upon small mammals and drop and molt to nymphs which, in some cases, may remain quiet until cool weather begins and then go into hibernation to appear as unengorged nymphs the following spring. Others probably become engorged and in the fall produce adults which pass the winter in that stage. The over-wintered nymphs appear somewhat later than the adults; they attach to small mammals, become engorged, and produce adults. The majority of these adults probably remain quiet during the summer and go into hibernation the following winter.

ECONOMIC IMPORTANCE.

While this species appears to be quite abundant in certain portions of the northwestern United States and more or less annoying to domesticated and wild animals, it is of particular importance because of the rôle it plays in the transmission of the causative organism of Rocky Mountain spotted fever. This is a disease of man which occurs in several of the Rocky Mountain States. It is of extreme importance in the Bitter Root Valley of Montana, where a number of cases occur each year, among which the mortality is usually about 70 per cent. In Idaho, however, the disease is much less virulent, the mortality not running above 5 to 8 per cent, although the number of cases in the southern part of this State frequently exceeds 300 per year. The occurrence of the disease is largely confined to the spring months March to June inclusive, or the period during which the adult ticks are most active.

NATURAL CONTROL.

Few observations relating to the natural enemies of this species appear to have been made. Chickens have been found to devour the engorged females with avidity when the ticks were fed to them. No doubt fowls eat a large number of ticks which drop from animals in the barnyard. In Colorado a species of blackbird was seen to devour the engorged ticks as they fell from cattle. Engorged females have been observed to be eaten by tame rabbits upon which specimens were being engorged. The little black ant, *Monomorium minimum,* was found on a number of occasions to have entered pill boxes which contained engorged larvæ and destroyed dozens of specimens.

ARTIFICIAL CONTROL.

As has been pointed out, the adults of the Rocky Mountain spotted-fever tick feed almost exclusively on the large domestic animals, while the small rodents are the principal hosts of the immature stages. This immediately suggests the idea of destroying the adult ticks on domestic animals. On account of the fact that many of the adults which appear in the late summer or fall from overwintered nymphs will hibernate before engorging, it will be necessary to continue the treatment of the hosts for at least two seasons. Dipping, swabbing, or hand picking would probably not be necessary except between the first appearance of the ticks in spring and June 15. As has been pointed out by Dr. Ricketts, the destruction of the small mammals which act as hosts for the immature stages would also aid in lessening the numbers of the tick.

THE PACIFIC COAST TICK.

Dermacentor occidentalis Neumann.

The common name of this tick is derived from the fact that it is known to occur only in the Pacific coast region of the United States.

DESCRIPTIVE.

Adult (Plate XII, figs. 8–12).—Males 2.8 by 1.6 mm. to 4.2 by 2.3 mm. Females, unengorged, 2.9 by 1.8 mm. to 3.6 by 2 mm.; engorged, 9 by 6.1 by 3.3 mm. to 11.8 by 7.6 by 5.6 mm. Unengorged males and females reddish brown, scutum in both sexes well covered with a whitish color resembling bloom, somewhat iridescent, interrupted by many red punctures; the same color on dorsal side of legs as on scutum. Engorged female steel-gray, dorsum with an olive-green surface color, which covers the gray except in small spots, thus giving a mottled appearance.

Nymph.—Unengorged, 1.13 by 0.63 to 1.26 by 0.65 mm.; engorged, 3.10 by 2.16 by 1.11 mm. Color light brown, lateral portions of scutum darker, the intestines, which show through, dark brown. Capitulum 0.32 mm. long (from tip of palpi to base of emargination of scutum); scutum 0.488 mm. long by 0.557 mm. wide.

Larva.—Unengorged, 0.643 by 0.426 mm.; engorged, 1.316 by 0.916 by 0.603 mm. Capitulum 0.139 mm. long (from tip of palpi to base of emargination of scutum); scutum 0.23 mm. long by 0.339 mm. wide. Color, unengorged, reddish brown; engorged, bluish gray.

Egg.—Ellipsoidal, amber to brown in color, shining, smooth. The maximum size of 10 eggs was 0.517 mm. by 0.402 mm., the minimum size 0.502 mm. by 0.387 mm., and the average size 0.51 mm. by 0.395 mm.

HOST RELATIONSHIP.

The host of the type specimen is the deer. As yet little is known regarding the hosts of the immature stages. They attach and engorge readily upon guinea pigs, rabbits, and bovines. Over 80 lots of adult ticks, in which the host animal was given, have been received from correspondents. The frequency of occurrence on different hosts was as follows: Cattle, 30; horse, 22; man, 16; deer, 4; mule, 4; dog, 3; ass, 1; rabbit, 1; sheep, 1. While cattle, horses, and man are the hosts upon which most of our collections have been made, deer act as hosts for large numbers of adults. In some cases they are said to be infested with thousands of specimens.

GEOGRAPHICAL DISTRIBUTION.

(Fig. 15.)

The type locality for this species is Occidental, Cal. Although this species has been reported from Texas, New Mexico, and Arizona, as well as California, it is very doubtful if the records from Texas, New Mexico, and Arizona are correct. Our records indicate that the species is confined to the Coast Range and Sierra Nevada Mountains in California and Oregon and the small mountain ranges in southwestern California. The species occurs in great abundance in the extreme southern part of California, and it is therefore almost certain to occur southward in Lower California and western Sonora.

LIFE HISTORY.

No previous work seems to have been done on the life history of this species. Investigators of Rocky Mountain spotted fever have published a number of notes regarding the life history of *Dermacentor venustus* under the name *Dermacentor occidentalis.*

The egg (Table LXXXII).—In the laboratory in June, at a mean temperature of 87.19° F., deposition began in one case in 4 days. In April, with a mean temperature of 66.18° F., one tick had a preoviposition period of 14 days. The longest preoviposition period actually noted was 17 days. This record was on a female which was collected and mailed to the laboratory, hence the temperature and moisture conditions were not normal. The average preoviposition period of 4 females dropped in April and May was 7¾ days. The average preoviposition of 17 lots of females collected during the period from March to June, inclusive, was 10.4 days. During April and May, 4 ticks showed a deposition period of from 27 to 39 days, with an average of 31¼ days. The mean temperature during the shortest period was 74.17° F. and during the longest period it was 70.99° F. These females died in from 1 to 7 days after deposition was completed. The average number of eggs deposited by the 4 females was 3,210 and the maximum number deposited by an individual was 4,555.

The minimum incubation period under laboratory conditions was 21 days. This record was made during June, 1910. The total effective temperature required for embryonic development appears to be at least 842° F. The last two lots of eggs, the hatching of which is recorded in the following table, were kept in an incubator during incubation and removed therefrom when hatching was complete.

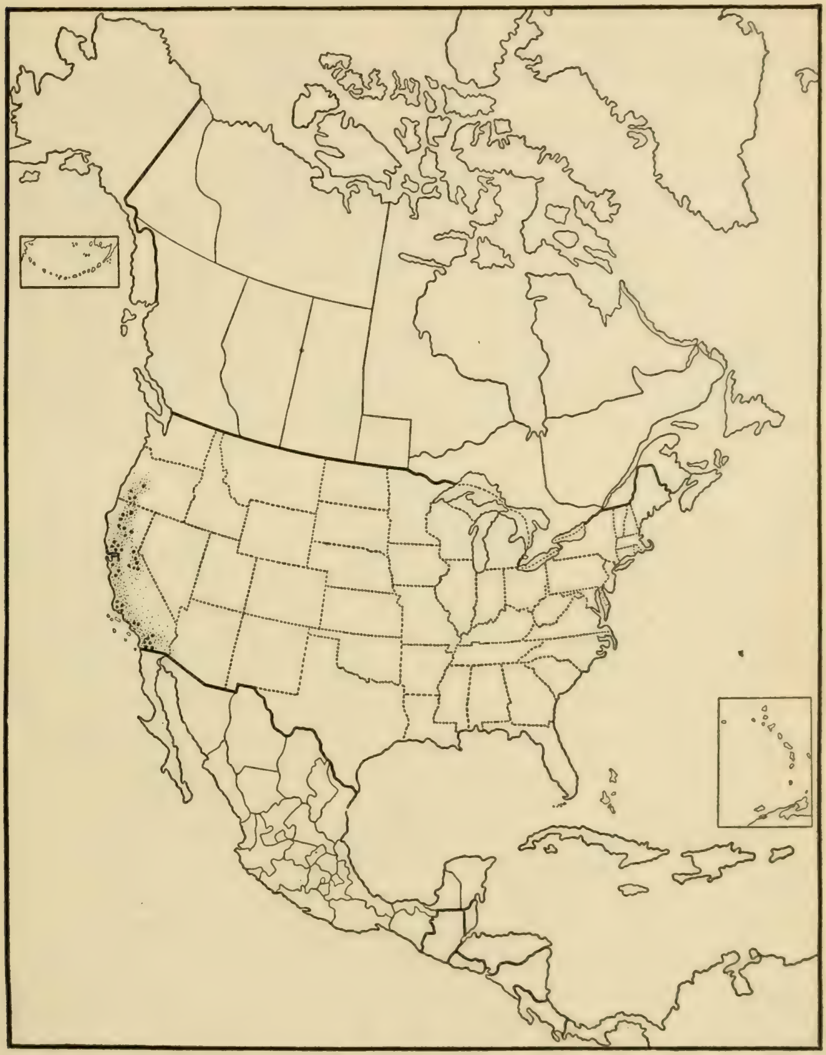

FIG. 15.—The Pacific Coast tick, *Dermacentor occidentalis:* Distribution in the United States. The large dots show localities where the species has been collected in our investigation. The small dots show the probable range of the tick. (Original.)

The incubation period was reduced to 16 days in these two instances, during which time the mean temperature was about 90° F.

TABLE LXXXII.—*Preoviposition, incubation, and longevity of larvæ of Dermacentor occidentalis.*

Date engorged female dropped or collected.	Deposition began.	Hatching began.	Minimum incubation period.	All larvæ dead.	Larval longevity.	Temperature during incubation.			
						Maximum.	Minimum.	Average daily mean.	Total effective.
1910.	1910.	1910.	*Days.*	1910.	*Days.*	°*F.*	°*F.*	°*F.*	°*F.*
Apr. 2 (collected)	Apr. 15	May 19	35	Before July 16.	58—	91	43	70.16	950.6
Do	Apr. 14	May 17	34	July 16–Aug. 4.	105–124	91	43	70.72	942.48
Apr. 11 (collected)	Apr. 21	May 25	35	July 18–Aug. 4.	54–71	91	43	71.43	1,012.0
Apr. 12 (collected)	Apr. 26	May 26	31	do	53–70	91	52.5	73.19	935.75
Apr. 13 (dropped)	Apr. 27	May 28	32	Before July 18.	51—	91	58.5	74.23	999.50
May 3 (collected)	May 10	June 16	38	July 18–Aug. 4.	32–49	100	59	77.92	1,326.9
Do	May 13	June 7	26	do	41–58	100	59	77.07	885.75
May 9 (dropped)	May 16	June 10	26	Aug. 4–12	55–63	100	60	79.28	943.25
May 11 (collected)	May 20	June 12	24	do	53–61	100	60	80.09	890.25
May 13 (collected)	May 23	June 14	23	July 18–Aug. 4.	44–61	100	60	80.25	856.75
May 15 (collected)	May 24	June 16	24	do	32–49	100	60	80.71	905.25
May 29 (dropped)	June 4	June 24	21	do	24–41	97	66	83.1	842
June 20 (dropped)	June 24	July 14	21	Aug. 12–20	29–37	98	73.5	85.7	896.75
Nov. 15 (collected)	Dec. 12	Dec. 27	[1] 16	Mar. 18, 1911	81			90 (about)	
Do	Dec. 16	Dec. 31	[1] 16	Mar. 14. 1911	73			90 (about)	

[1] Kept in incubator during incubation.

The larva (Tables LXXXII–LXXXV).—The longevity of the larvæ of this species is somewhat shorter than that of most of the other species of the genus Dermacentor. The greatest longevity accurately recorded occurred in the case of a lot of larvæ which hatched May 17 and on subsequent days. The longest-lived larvæ of this lot died between 105 and 124 days after hatching began. A large number of records of larval longevity were made on the progeny of individual ticks. In the majority of the lots all larvæ were dead within two months after the hatching of the eggs began. All of the records on longevity were made upon larvæ kept in tubes with cotton stoppers, on moist sand in the laboratory.

Engorgement may be completed as soon as 3 days after attachment to a host. The greatest number of engorged larvæ dropped from the host on the third, fourth, and fifth days after attachment. A single larva was found to have dropped the second day, but since this specimen was not fully engorged it is quite probable that it was rubbed off by the host. This statement probably applies to all larvæ which were found to have dropped before becoming fully engorged. The longest period required for engorgement was 7 days. In most instances larvæ were found to attach within a few hours after being applied to a host. In our experiments only a small percentage of the number of larvæ put on a host ever reached engorgement.

TABLE LXXXIII.—*Engorgement of larvæ of Dermacentor occidentalis.*

Date larvæ applied.	Host.	Number.	Larvæ dropped engorged—days following application.							Total number dropped.	State of engorgement.
			1	2	3	4	5	6	7		
1910.											
May 24	Bovine	1,000	0	1	38	10	3	....	....	52	Two-thirds to fully.
June 10	.....do	700	0	0	27	6	....	....	....	33	Fully.
June 21	.....do	400	0	0	0	0	2	....	....	2	(?)
June 27	.....do	150	0	0	11	11	....	....	....	22	Fully.
July 6	Guinea pig	500	0	0	130	60	206	4	....	400	Two-thirds to fully.
July 9	Bovine	300	0	0	0	4	2	....	....	6	Fully.
July 19	.....do	200	0	0	0	8	6	1	....	15	Two-thirds to fully.
Aug. 9	.....do	200	0	0	4	....	....	....	....	4	Fully.
Aug. 25	Guinea pig	50	0	0	0	0	10	4	1	15	Do.

TABLE LXXXIV.—*Rapidity of engorgement of larvæ of Dermacentor occidentalis applied to guinea pig at 11 a. m., July 6, 1910.*

Engorged larvæ dropped (tray examined).	Number.	Period from application.	Percentage of total dropped.	Engorged larvæ dropped (tray examined).	Number.	Period from application.	Percentage of total dropped.
		Hours.				*Hours.*	
July 9, 9 a. m	6	70	1.5	July 10, — p. m	35	(?)	8.75
July 9, 2 p. m	10	75	2.5	July 11, 9 a. m	117	94	29.25
July 9, 4.35 p. m	90	77½	22.5	July 11, 11.30 a. m	78	96½	19.50
July 9, 5.05 p. m	19	78	4.75	July 11, 5 p. m	11	102	2.75
July 9, 5.30 p. m	5	78½	1.25	July 12, 9 a. m	4	118	1.00
July 10, — p. m	25	(?)	6.25				

In July, at a mean temperature of 86.82° F., molting began in 6 days. This transformation appears to require a total effective temperature of 263° F.

TABLE LXXXV.—*Molting of engorged larvæ of Dermacentor occidentalis.*

Date engorged larvæ dropped.	Host.	Number.	Engorged larvæ molted—days following dropping.							Total number molted.	Temperature from dropping to date first tick molted.		
			6	7	8	9	10	11	12		Maximum.	Minimum.	Average daily mean.
1910.											*°F.*	*°F.*	*°F.*
May 27, a. m	Bovine	38	...	...	5	(1)	25	0	2	32	100	71.50	83.47
May 28, a. m	.....do	10	...	...	...	...	4	...	...	4	100	73	83.57
May 29, a. m	.....do	3	...	...	...	...	1	...	...	1	100	73	84.04
June 13, a. m	.....do	15	...	...	3	4	3	...	...	10	97	69	83.05
June 13, p. m	.....do	8	...	...	...	...	3	1	...	4	97	69	83.05
June 14, a. m	.....do	6	...	...	2	2	...	...	...	4	97	69	84.52
June 30, p. m	.....do	11	...	...	5	...	...	2	...	7	98	73.5	86.64
July 9	Guinea pig	16	...	...	(1)	16	...	...	...	16	103.5	76	86.4
July 9, p. m	.....do	90	...	...	(1)	15	...	...	...	15	103.5	76	86.4
July 9, p. m	.....do	24	...	...	(1)	24	...	...	...	24	103.5	76	86.4
July 10, a. m	.....do	25	...	(1)	19	...	...	...	...	19	103.5	76	86.78
July 11, a. m	.....do	117	(1)	100	...	...	...	...	...	100	103.5	76	86.82
July 11, p. m	.....do	89	(1)	78	0	2	...	...	...	80	103.5	76	86.82
July 12, a. m	.....do	4	2	...	...	...	...	...	...	2	103.5	76	86.83
July 13, a. m	Bovine	4	...	4	...	...	...	...	...	4	103.5	74	87.75
July 23, a. m	.....do	6	...	...	4	...	...	...	...	4	102	80	89.29
Aug. 12, a. m	.....do	1	...	1	...	...	...	...	...	1	103.5	82	92.37
Aug. 30, a. m	.....do	4	...	1	...	1	1	...	...	3	98	75	87.31
Aug. 30, p. m	.....do	6	...	5	...	...	...	...	...	5	98	75	87.31
Aug. 31, a. m	.....do	4	...	...	...	...	2	...	...	2	98	72.50	86.16
	Total	481	...	...	...	...	...	...	...	337	......	......	......

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[1] The larvæ which molted on this day are included with those on the following day.

The nymph (Tables LXXXV–LXXXVII).—The longevity of the nymphs of this tick is shorter than that of any other species of Dermacentor studied by us with the possible exception of those species which molt on the host. The records made indicate that during the hot summer months the longevity ranges between 40 and 60 days. The greatest longevity observed was between 76 and 108 days. This record was made in the fall months. These nymphs were kept in glass tubes with cotton stoppers on moist sand in the laboratory. It is probable that during cool weather a somewhat greater period of longevity would occur.

TABLE LXXXV.—*Longevity of nymphs of Dermacentor occidentalis.*

Date larvæ molted to nymphs.	Number.	Number put on host.	All larvæ dead.	Larval longevity.
1910.			1910.	*Days.*
June 4–8	37	0	July 18 to Aug. 4	40–61.
June 21–24	18	0	Aug. 4 to Aug. 12	41–52.
July 17–20	300	230	Aug. 12 to Sept. 24	23–69.
July 31 to Aug. 12	4	0	Before Oct. 26	Less than 75.
Aug. 17	1	0	do	Less than 70.
Sept. 6–10	10	0	Nov. 25 to Dec. 23	76–108.

TABLE LXXXVI.—*Engorgement of nymphs of Dermacentor occidentalis.*

Date nymphs applied.	Host.	Number.	Nymphs dropped—days following application.							Total number dropped.	State of engorgement.
			3	4	5	6	7	8	9		
1910.											
July 19[1]	Guinea pig	(?)	8	3	5	4	....	....	....	20	Fully.
July 26	do	30	....	....	....	7	1	1	1	10	One-fourth to fully.
July 30	Bovine	4	....	....	....	1	....	....	....	1	One-third.
Aug. 6	Rabbit	200	....	12	32	18	8	....	2	72	One-half to fully.
Aug. 5[1]	Guinea pig	(?)	....	....	2	....	....	....	....	2	Fully.

[1] These lots were accidental infestations, hence the exact date of attachment is not known.

The shortest period of engorgement accurately observed was 4 days; the longest, 9 days. In the last instance the nymphs were still only about one-half engorged and were probably scratched off by the host. The weighted average engorgement period of all nymphs upon which accurate records were made is 5.56 days. Attachment was observed to take place, in most cases, almost immediately after the ticks had been placed on the host.

TABLE LXXXVII.—*Molting of engorged nymphs of Dermacentor occidentalis.*

Date engorged nymphs dropped.	Host.	Number.	Engorged nymphs molted—days following dropping.									Number molted.			Temperature from dropping to date first tick molted.		
			13	14	15	16	17	18	19	21	22	Male.	Female.	Total.	Maximum.	Minimum.	Average daily mean.
1910.															°F.	°F.	°F.
June 12, p. m.	Guinea pig	1									1♀	...	1	1	103	77.50	90.10
July 22, a. m.	do	4			1♀		1♂ 1♀					1	2	3	103	77.50	90.19
July 22, p. m.	do	4				(1)	1♂ 3♀					1	3	4	98	66	69.36
July 23, a. m.	do	3			2♂	1♀						2	1	3	103	79	90.27
July 24, a. m.	do	5				1♂ 2♀	1♀	1♀				1	4	5	103	79	90.23
July 25	do	4					1♂		1♂	1♂		3	0	3	103	79	90.21
July 30	do	1				1♂						1	0	1	103.5	79	91.04
Aug. 1, a. m.	do	7		3								?	?	3	103.5	79	91.18
Aug. 2, a. m.	Rabbit	1			1♀							0	1	1	103.5	79	91.00
Aug. 3, a. m.	Guinea pig	1					1					?	?	1	103.5	79	90.96
Aug. 10	do	2		1♂		1♂						2	0	2	104.5	79	92.32
Aug. 10, a. m.	Rabbit	2		2♂								2	0	2	104.5	79	92.32
Aug. 10, p. m.	do	10	2♀	1♂	2♂ 2♀	1♂ 1♀	1♀					4	6	10	104.5	78	92.38
Aug. 11, a. m.	do	10			1♂	1♂	1♂ 2♀	1♀				3	3	6	104.5	73	91.32
Aug. 11, m. noon.	do	7	1♂		1♂ 1♀		(1)	1♂ 1♀				3	2	5	104.5	79	92.44
Aug. 11, p. m.	do	13		1♀	3♂ 2♀	1♂ 2♀	1♂ 1♀	1♂				6	6	12	104.5	79	92.13
Aug. 12, a. m.	do	12	1♀		2♂	(1)	1♂ 3♀	1♂	1♀			4	5	9	104.5	80	91.96
Aug. 12, p. m.	do	6			1♂ 1♀	2♀	1♂	1♀				2	4	6	104.5	73	90.53
Aug. 13, a. m.	do	3			(1)	1♂ 1♀						1	1	2	104.5	73	90.15
Aug. 13, p. m.	do	5			1♀	3♂	1♂					4	1	5	104.5	73	90.15
Aug. 15, a. m.	do	2			2♂							2	0	2	104.5	73	89.67
	Total	103										42	40	86			

[1] The ticks which molted on this date are included with those recorded on the following day.

In August, 1910, at a daily mean temperature of from 91.96° to 92.44° F. molting commenced on the thirteenth day. The longest period from dropping to molting was 22 days. This occurred at a daily mean temperature of 69.36° F. The males and females began to appear about the same number of days after dropping. The weighted average molting period of 42 nymphs which transformed to males was 15.89 days. In the case of 40 females this average was 16.22 days. The weighted average period from dropping to molting for all nymphs observed was 15.62 days. A total effective temperature of 636.5° F. seems to be required for this transformation.

The adult (Tables LXXXVIII–LXXXIX).—The number of males and females which molted from nymphs was practically equal. The greatest longevity which has been observed was 359 days. This record was made on a lot of 29 males and 29 females which molted from nymphs August 10, 1910. The last male in this lot died May 31, 1911. It had lived 294 days. The females appear to have a slightly greater longevity than do the males; this is particularly noticeable among those ticks which have once been attached to a host in the adult stage. Hot weather also appears materially to shorten the longevity of both sexes.

TABLE LXXXVIII.—*Longevity of adults of Dermacentor occidentalis.*

Date molted or collected.	Number.		All dead.	Longevity.
	Male.	Female.		
1910.				*Days.*
Molted, July 4	0	1	Oct. 18–Nov. 28, 1910	106–147
Molted, Aug. 10	29	29	Aug. 4, 1911	359
Molted, Aug. 15	1		May 27, 1911	285
Molted, Aug. 15–20	2	2	May 8, 1911	266
Molted, Aug. 17	0	1	Nov. 28–Dec. 20, 1910	103–125
Molted, Aug. 24	2	0	May 20, 1911	269
Collected, Apr. 2	0	1	July 19–Aug. 18, 1910	118–147
Do	1	7	June 7, 1910	66
Collected, Apr. 5	2	8	Aug. 18–31, 1910	135–148
Collected, Apr. 8	8	4	June 18–July 18, 1910	71–101
Collected, Apr. 27	0	5	July 18–Aug. 18, 1910	82–113
Collected, May 28	0	2	....do	51–82
Collected, Oct. 1	6	5	Apr. 5, 1911	166
Collected, Oct. 26	0	1	Mar. 20, 1911	145

Copulation of this species has not been observed before attaching to a host. Mating has been seen to take place upon bovine hosts any time between one and several days after attachment. In one case a female became fully one-half engorged before she was visited by a male. One female which was not observed to be fertilized became nearly engorged and dropped in about the normal engorgement period. However, no eggs were deposited by this individual.

TABLE LXXXIX.—*Engorgement of adults of Dermacentor occidentalis on bovines.*

Date females applied.	Number.	State of engorgement.	Date attached.	Females dropped engorged—days following attachment.								State of engorgement.
				2	4	6	7	9	10	17	Total number dropped.	
1910.			1910.									
Apr. 9	5	Slightly to one-fifth.	Apr. 9	...	...	1	...	...	...	...	1	Fully.
Apr. 22	2	Unengorged.	Apr. 22	...	...	...	...	...	...	1	1	Two-thirds.
May 9	10	Unengorged to one-eighth.	May 9	4	1	...	...	...	...	...	5	One-fourth to two-thirds.
May 20	1	Unengorged.	May 20	...	...	...	...	1	...	...	1	One-half.
June 4	3	Slightly	June 4	...	...	1	...	...	...	...	1	Two-thirds.
June 14	2	.....do	June 15	...	...	...	1	...	...	...	1	Do.
Aug. 26–31	8	Unengorged.	Aug. 31–Sept. 4.	...	...	...	1	...	1	...	2	Fully.
Sept. 22	4	.....do	Sept. 24	...	...	...	1	...	...	...	1	One-eighth.

Males have been observed to remain upon a host for 31 days. Females which had become one-fifth engorged upon one host were found to attach to another host when given an opportunity. In most cases ticks applied to a bovine attached within less than one day thereafter, but in a few instances both males and females were found to remain unattached for 4 or 5 days, some of these dying in the meantime. The females which became detached before becoming fully engorged, as indicated in Table LXXXIX, were undoubtedly dislodged by the rubbing of the host. The shortest period in which females were known to become fully engorged was 6 days; the longest period was 17 days. In the last instance the female was only two-thirds engorged when she was detached.

LIFE CYCLE.

A period of at least 105 days elapsed between the beginning of hatching of the eggs deposited by a female and the death of the last larva. The larvæ may engorge in 3 days after attachment and in summer molt as soon as 6 days after dropping. The transformation from larvæ to nymphs requires a total effective temperature of 263° F. Nymphs may live at least as long as 76 days during cool weather; they engorge as soon as 4 days after attachment and may molt as soon as 13 days after dropping. The molting period for nymphs which become males and those which become females is practically the same. A total effective temperature of 636° F. is required to produce this molt. Adults may live as long as 359 days. Females may engorge in 6 days, commence depositing in 4 days after dropping, and deposit as many as 4,555 eggs. The eggs hatch as soon as 21 days after deposition and appear to require a total effective temperature of about 842° F. for incubation.

This tick has been found to occur in nature at all seasons of the year. The adults appear to become most numerous during the rainy season. Many engorged females are to be found on hosts during December.

ECONOMIC IMPORTANCE.

Owing to the fact that this tick frequently attacks man and often occurs in great abundance on domestic live stock, it is of considerable economic importance in California and Oregon. Its presence throughout the entire season in greater or less numbers also increases its importance. Where it occurs it is usually spoken of as the "wood tick." In central and western California and western Oregon it is the most common tick which attacks man. A number of cases have been brought to our attention where the bite of this tick has caused considerable local inflammation which, in some cases, has required a physician's attention. It is quite common for the rostrum to be broken off when the ticks are removed and in such cases the irritation and itching usually persists for several weeks.

Although numerous authors have used the name *Dermacentor occidentalis* in connection with Rocky Mountain spotted fever, it is doubtful if this species is concerned in the transmission of that disease. The use of the name was due to confusion regarding the identity of the tick *Dermacentor venustus*, which is the known transmitter of this disease in nature.

NATURAL CONTROL.

No natural enemies of this species have been observed by the writers. However, it is probably subject to the attack of the various predaceous enemies of other tick species. McAtee (1911a) states that ticks of this species have been found to be eaten by the dwarf hermit thrush (*Hylocichla guttata nana*).

ARTIFICIAL CONTROL.

The comparatively short longevity of the larvæ and nymphs of this species indicates that it may be possible to practice the rotation method of eradication. This method appears to be more promising than the use of dips on account of the fact that the engorgement period of the immature stages is quite short and usually takes place on small wild mammals. The occurrence of the species throughout the year is also an obstacle to the practice of dipping or mopping animals with tickicides.

THE AMERICAN DOG TICK.

Dermacentor variabilis (Say).

The common name of this tick is given it because in this country it is the most widely distributed species which commonly attacks the dog.

DESCRIPTIVE.

Adult (Pl. XV, figs. 5–11).—Males from 3.5 by 2.5 to 4.5 by 2.5 mm. Females, unengorged, about 3.75 by 2.25 mm.; engorged, 10 by 7 by 5 to 15.5 by 11.2 by 7.4 mm. Male reddish brown, dorsum with irregular white marks; female reddish brown, scutum with a white band on the lateral margin, broadening posteriorly; a brown marginal stripe near each eye and sometimes two white median stripes.

Nymph (Pl. XV, figs. 2–4).—Unengorged, about 1.5 by 1 mm.; engorged, 3.5 by 2 by 1 mm. to 4 by 3 by 2 mm.; average 3.5 by 2.5 by 1.5 mm. Color, unengorged, pale yellowish brown; posterior margin of scutum dark brown, lateral margins of scutum with brick-red markings; in living specimens the intestines are visible as brown bands through the body walls; engorged, slate-gray. Capitulum 0.287 mm. long (from tip of palpi to base of emargination of scutum); scutum 0.488 mm. long by 0.526 mm. wide.

Larva (Pl. XV, fig. 1).—Unengorged, about 0.60 by 0.35 mm.; engorged, 1.5 by 1 mm. Color, unengorged, pale yellow; lateral margins of scutum brick-red; engorged, dull gray. Capitulum 0.17

mm. long (from tip of palpi to base of emargination of scutum); scutum 0.255 mm. long by 0.32 mm. wide.

Egg.—Ellipsoidal, pale yellowish brown, shining, smooth. The average size of those measured was 0.527 by 0.379 mm.

HOST RELATIONSHIP.

The host of the type is not recorded. The dog is the most common host of the adult stage of this species. Out of 112 lots collected by agents of the bureau the following numbers of lots were taken on the different hosts listed: Dog 62, fox squirrel 9, raccoon 6, opossum 6, ox 5, badger 3, coyote 3, skunk 3, deer 2, man 2, wolf 2, ass 1, Mexican lion (*Felis hippolestes aztecus*) 1, fox 1, hog 1, horse 1, rabbit 1, weasel 1, wild cat 1. The lot from the Mexican lion, consisting of 9 males and 3 females, was collected by Mr. D. K. McMillan at Raymondville, Tex., November 20, 1910.

No larvæ known to be of this species have been collected, but a considerable number of nymphs have been taken on fox squirrels and one lot was collected on a swamp rabbit (*Lepus aquaticus*). Adults of both sexes were taken on the fox squirrels along with the nymphs. Most of the lots collected on this host were taken by Mr. J. D. Mitchell in March and April, 1909. In rearing experiments larvæ attached to a bovine, but failed to attach to dogs, even after several attempts were made.

GEOGRAPHICAL DISTRIBUTION.

(Fig. 16.)

The locality from which the type was described is not recorded.

The determination of the distribution of this species is complicated through questionable identification due to the fact that, superficially, it closely resembles several other species.

The species is common throughout the eastern half of the United States. It is recorded from Alaska, Labrador, Ontario, and Nova Scotia on the north and its range extends southward through the United States to the Gulf coast. There is also one record from Mexico. Although the species has been listed from Colorado, New Mexico, and Arizona, our investigations indicate that it does not normally occur in those States. There is, however, a considerable area in western California and southwestern Oregon where the species is very common. In this region and in the Central and Southern States the species appears to occur most abundantly.

LIFE HISTORY.

Observations on the biology of this tick have been published by Morgan (1899, pp. 133, 135), Hunter and Hooker (1907, pp. 50–51), and by Hooker (1908, p. 47).

The egg (Table XC).—The minimum preoviposition period for a large number of ticks observed at different times of the year was 5 days and the maximum 14 days. This minimum preoviposition period was observed in a number of instances during the summer months, while the maximum period was recorded once in March and once in April, 1909. The mean temperature during the shortest period was 80° F. The period of oviposition varied from 14 to 29 days with an average of 22.3 days. A tick which was collected on a

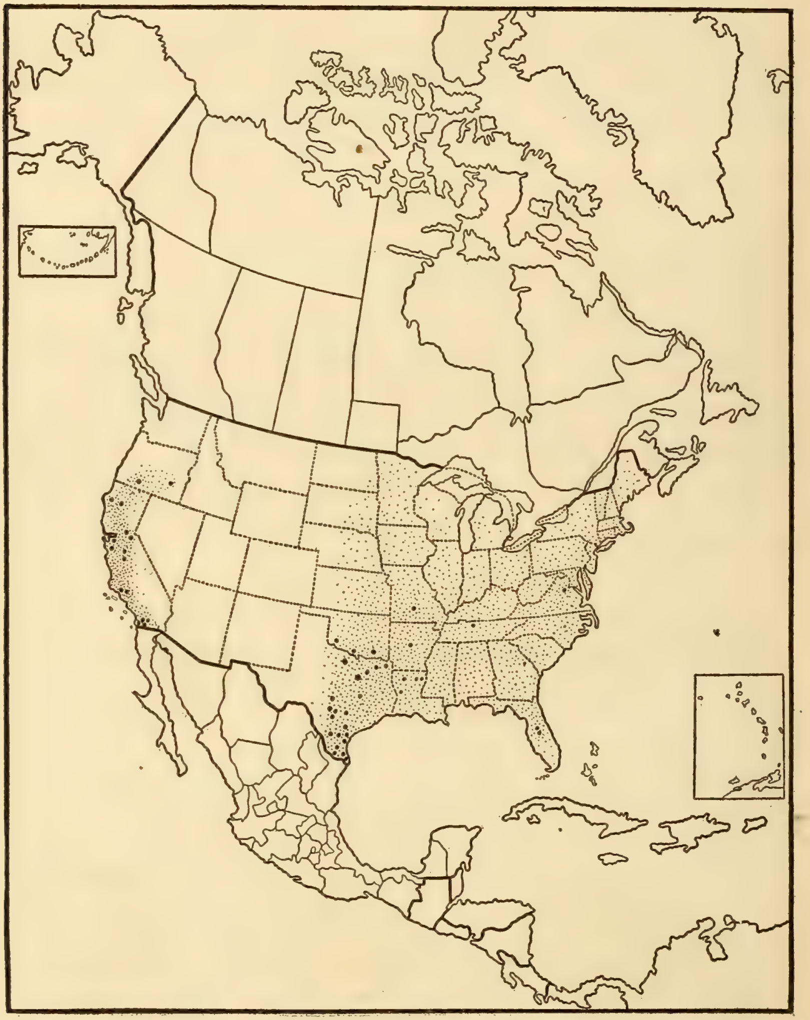
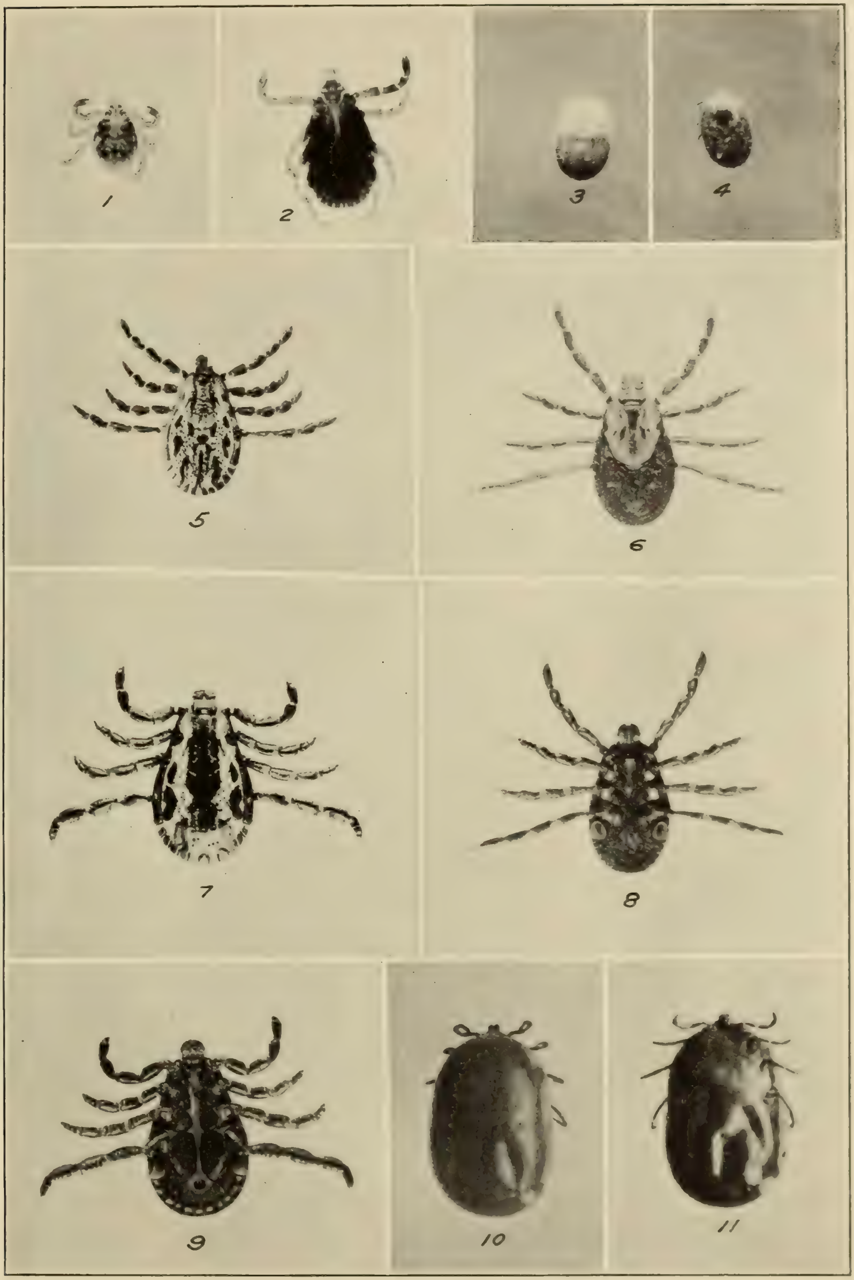


FIG. 16.—The American dog tick, *Dermacentor variabilis:* Distribution in the United States. The large dots show localities where the species has been collected in our investigation. The small dots indicate the probable range of the tick. (Original.)



THE AMERICAN DOG TICK, DERMACENTOR VARIABILIS.

Fig. 1.—Unengorged larva. Fig. 2.—Unengorged nymph (balsam mount). Fig. 3.—Engorged nymph about to molt to female. Fig. 4.—Engorged nymph about to molt to male. Fig. 5.—Male, dorsal view (Texas form). Fig. 6.—Unengorged female, dorsal view. Fig. 7.—Male, dorsal view (Oregon form). Fig. 8.—Unengorged female, ventral view. Fig. 9.—Male, ventral view. Fig. 10.—Engorged female, dorsal view. Fig. 11.—Engorged female, ventral view. (Original.)

dog August 10, 1909, measured 15.5 by 11.2 by 7.4 mm. It began depositing on the sixth day and continued depositing for 23 days, during which time 6,855 eggs were deposited. This is the maximum number of eggs recorded by us for the species, but Prof. H. A. Morgan (1899) has recorded 7,378 as being deposited by one tick between May 8 and June 26. The minimum number of eggs deposited by 11 ticks was 2,808, the average 4,568.

The minimum incubation period for eggs kept in tubes out of doors was 24 days. This record was made on eggs deposited August 17, 1907. Eggs kept in the laboratory at a mean temperature of 84° F. hatched in 20 days. An effective temperature of at least 825° F. appears to be required for their incubation.

TABLE XC.—*Incubation and longevity of larvæ of Dermacentor variabilis.*

IN LABORATORY.

Eggs deposited.	Hatching began.	Minimum incubation period.	All larvæ dead.	Larval longevity.	Temperature during incubation.			
					Maximum.	Minimum.	Average daily mean.	Total effective.
1908.	1908.	*Days.*		*Days.*	*°F.*	*°F.*	*°F.*	*°F.*
Apr. 11	May 18	38			86	47	70.41	1,041.50
June 4	June 28	25	Oct. 4, 1908	98	91.5	69	80.98	949.50
June 10	July 3	24	Oct. 6, 1908	95	91	69	80.33	895.75
June 12	July 14	33	Oct. 4, 1908	82	93	70.5	81.31	1,264.25
July 4	July 25	22	May 17, 1909	296	95	70.5	83.26	888
July 6	July 27	22	June 10, 1909	318	95	74	83.86	899
July 7	do	21	June 27, 1909	335	95	74	83.98	860.50
July 11	July 30	20	Apr. 16–May 7, 1909	260–281	95	74	84.26	825.25
July 12	Aug. 1	21	Nov. 9–16, 1908	100–107	95	74	84.29	867
July 15	Aug. 4	21	May 8–15, 1909	277–284	95	76.5	85	882
July 17	Aug. 6	21	June 10, 1909	308	95	76	85.18	886.75
Aug. 16, 1909	Sept. 8, 1909	24	Jan. 28–Feb. 25, 1910	142–170	110	77	89.39	1,112.75
Apr. 25, 1910	May 31, 1910	37	July 19–Aug. 4, 1910	49–65	93	43	73.89	1,143
May 7, 1910	June 6, 1910	31	Mar. 15, 1911	282	100	59	76.62	1,042.25
May 9, 1910	June 8, 1910	31	July 19–Aug. 4, 1910	41–57	100	59	77.42	1,067
May 17, 1910	June 11, 1910	26	Feb. 5, 1911	239	100	60	79.30	943.80

OUT OF DOORS.

Eggs deposited.	Hatching began.	Minimum incubation period.	All larvæ dead.	Larval longevity.	Maximum.	Minimum.	Average daily mean.	Total effective.
Apr. 13, 1906	May 25, 1906	43			93	41.5	68.73	1,106
May 5, 1906	June 8, 1906	35			93	42	72.94	1,048
June 25, 1907	July 21, 1907	27			99	63.5	81.30	1,034
Aug. 17, 1908	Sept. 9, 1908	24	May 29, 1909	262	100	64	80.85	908.40
June ?, 1910	July 9, 1910		Dec. 23–31, 1910	167–175				
Aug. 9, 1910	Sept. 4, 1910	27	Mar. 17, 1911	194	105.6	66.7	86.49	1,174.25
Aug. 11, 1910	do	25			105.6	66.7	86.5	1,087

The larva (Tables XC-XCII).—The greatest longevity of the larvæ of this species recorded by us was 335 days. This lot of larvæ hatched out June 27, 1908, and was kept in a glass tube on moist sand in the laboratory. One lot of larvæ kept in a tube out of doors lived 262 days. The incubation and larval longevity records given in Table XC are a few from a large number of records selected to illustrate the variation in these developmental periods. As may be seen in the table, the longevity of the different lots varies greatly. We have not been able to account satisfactorily for the large differences in lots kept under similar conditions.

The shortest time in which engorgement took place was 4 days, the greatest number dropping from the host on the fourth to sixth days, while the last to leave the host dropped on the seventh day.

TABLE XCI.—*Engorgement of larvæ of Dermacentor variabilis.*

Date larvæ applied.	Host.	Larvæ dropped engorged—days following application.							Total number dropped.
		1	2	3	4	5	6	7	
July 31, 1907	Bovine	0	0	0	3	3	0	0	6
Aug. 5, 1907	...do	0	0	0	37	27	2	0	66
June 5, 1908	...do	0	0	0	5	17	24	3	49
Aug. 18, 1908	...do	0	0	0	0	0	5	0	5

Molting occurred in August as soon as the seventh day after dropping. At a mean temperature of 81° F. molting took place in 8 days, during which time a total of 306° F. of effective temperature accumulated.

TABLE XCII.—*Molting of engorged larvæ of Dermacentor variabilis.*

Date engorged larvæ dropped.	Host.	Number.	Engorged larvæ molted—days following dropping.						Total number molted.	Temperature from dropping to date first tick molted.		
			7	8	9	10	11	12		Maximum.	Minimum.	Average daily mean.
										° *F.*	° *F.*	° *F.*
Aug. 4, 1907	Bovine	3	0	0	1	1	1	0	3	....	....	....
Aug. 5, 1907	...do	3	0	2	1	0	0	0	3	....	....	....
Aug. 9, 1907	...do	37	9	18	1	0	0	0	28	....	....	....
Aug. 10, 1907	...do	26	4	12	4	3	1	0	24	....	....	....
Sept. 7, 1907	Dog	1	0	0	0	0	1	0	1	....	....	....
June 9, 1908	Bovine	5	0	0	2	2	0	0	4	91.5	69	79.87
June 10, 1908	...do	18	0	0	8	4	4	0	16	91.5	69	80.50
June 11, 1908	...do	24	0	3	7	3	1	0	14	91.5	70	81.19
June 12, 1908	...do	3	0	2	0	0	0	0	2	91.5	71.5	81.39
Aug. 24, 1908	...do	5	0	0	1	2	2	0	5	90	75.5	83.27
	Total	125	....	....	....	....	....	....	100	....	....	....

The nymph (Tables XCIII-XCIV).—A number of nymphs which molted on August 18, 1907, were alive March 5, 1908, but dead on March 21, 1908, the longevity of this lot being from 7 to 8 months. In another instance, however, nymphs which molted on June 18, 1908, were dead on August 4 of that year, and the last individuals of a third lot, which molted September 9, 1908, died between October 16 and October 26 of the same year. All of these lots were kept on moist sand in the laboratory.

The shortest period of engorgement recorded in our observations was 4 days. The last nymph to drop left the host on the eighth day.

TABLE XCIII.—*Engorgement of nymphs of Dermacentor variabilis.*

Date nymphs applied.	Host.	Nymphs dropped engorged—days following application.								Total number dropped.
		1	2	3	4	5	6	7	8	
Aug. 27, 1907	Bovine	0	0	0	0	2	1	1	1	5
Aug. 28, 1907	Dog	0	0	0	4	1	0	0	0	5

Engorged nymphs which dropped September 1 commenced to molt on the seventeenth day. One nymph which dropped August 28, 1909, molted on the sixteenth day after dropping. During this period the maximum temperature was 101° F., the minimum 78.5° F., the average daily mean 89.3° F., and the total effective temperature 740.8° F.

TABLE XCIV.—*Molting of engorged nymphs of Dermacentor variabilis.*

Date engorged nymphs dropped.	Host.	Number.	Engorged nymphs molted—days following dropping.										Number molted.		
			16	17	18	19	20	21	22	23	24	25	Male.	Female.	Total.
Feb. 26, 1907	Rabbit[1]	2	0	0	0	0	0	0	0	0	0	1♀	....	1	1+
Sept. 1, 1907	Bovine	5	0	1♂	1♂	1♀	2♀	0	0	0	0	0	2	3	5
Sept. 2, 1907	...do	2	0	1♂	1♂	0	0	0	0	0	0	0	2	0	2
Sept. 3, 1907	...do	1	0	0	1♀	0	0	0	0	0	0	0	0	1	1
Sept. 4, 1907	...do	1	0	0	1♀	0	0	0	0	0	0	0	0	1	1
Aug. 28, 1909	Squirrel	1	1♀	0	0	0	0	0	0	0	0	0	0	1	1
	Total	12	....	....	....	....	....	....	....	....	....	....	4	7	11+

[1] Collected from a swamp rabbit.

The adult (Table XCV).—The maximum adult longevity observed by us was 233 days. This record was made on a single female which became adult September 13, 1909. A female which was collected on an opossum May 10, 1910, lived 202 days, and one male in a lot consisting of 2 males and 3 females, which were collected on a squirrel April 6, lived 106 days. Other lots of collected individuals lived from 15 to 93 days. If a large number of freshly molted individuals were kept for longevity tests without allowing them to feed it is probable that some individuals would be found to live longer than any observed by us.

In our observations mating has been preceded by a period of feeding of from 3 or 4 to 10 or more days after attaching to a host and has continued for a day or so only. Females have been found to reattach even when engorged to a considerable extent. Unengorged females taken from dogs to which they had attached, and on which they had probably mated, engorged as soon as 5 days. Nine days was the shortest period in which previously unattached females engorged. Morgan, however, states that females engorge in from 5 to 8 days.

During engorgement the females constantly excrete what appears to be undigested blood. The adults also void considerable excrement soon after molting from nymphs.

A male which, with a female, was placed upon an ox November 1, 1907, remained upon the host, frequently changing its position, until February 14, when it was found attached but dead. Thus it remained upon the host for 105 days from its attachment and 91 days after the female had dropped engorged. Other males have disappeared from the host on the eighth day after the females dropped.

TABLE XCV.—*Engorgement of females of Dermacentor variabilis.*

Adults applied.	Host.	Females dropped engorged.	Period of attachment.	Size engorged.
			Days.	
Nov. 1, 1907	Bovine	Nov. 15	14	13 by 9 by 5 mm.
Mar. 23, 1908	do	Apr. 1	9	12 by 9 by 5 mm.
June 19, 1908	Bovine (reattached)	June 24	5	13 by 11 by 7 mm.
Do	do	June 25	6	13 by 11 by 7.5 mm.
Do	do	June 26 (5)	7	12 by 9 by 6.5 mm. 12.5 by 9.5 by 8 mm. 13 by 10 by 8 mm. 13 by 9 by 7 mm. 13 by 10 by 7 mm.
Do	Bovine	June 27	8	12.5 by 10 by 7.5 mm.
Aug. 24, 1908 (slightly engorged).	Bovine (reattached)	Aug. 30	6	12 by 7 by — mm.
Aug. 24, 1908	do	Aug. 31	7	10 by 7 by 5 mm.
Apr. 19, 1909	do	Apr. 27	8	13.8 by 9.4 by 7.3 mm
Sept. 8, 1909	do	Sept. 16	8	Fully engorged.
Do	do	Sept. 17	9	Partly engorged.
Mar. 26, 1910	do	Apr. 11	16	One-third engorged.

LIFE CYCLE.

Larvæ may live for 335 days; they may engorge as soon as 4 days after application to a host and molt as soon as 7 days after dropping, a total effective temperature of 306° F. being required for molting. Nymphs may live for from 7 to 8 months; they engorge as soon as 4 days after attachment and may molt as soon as 16 days after dropping. A total effective temperature of about 741° F. appears to be required for this transformation. Adults may live as long as 233 days; they may engorge in 8 days (5 days ?) and commence ovipositing as soon as 5 days after dropping. As many as 7,378 eggs may be deposited. Embryonic development may be completed in 20 days, a total effective temperature of 825° F. being required.

Adults of this tick have been collected on animals in Texas at all times of the year. However, they appear to be most abundant in the spring and early summer. Nymphs have been collected on animals in considerable numbers in February, March, and April, and in one instance in August. With little doubt the immature stages are to be found on hosts nearly all the year round.

ECONOMIC IMPORTANCE.

Aside from the fact that this species occasionally attaches to man and domestic animals and often causes considerable annoyance, it is of no economic importance. The ticks are easily removed from a host and their attachment has not been known to produce any serious consequences.

NATURAL CONTROL.

The many bird and other enemies of the cattle tick undoubtedly prey upon this tick also. Dogs have been observed by us to crush them with the teeth, both when attaching and after dropping.

ARTIFICIAL CONTROL.

This species has not been found to occur in numbers except upon the dog and some wild mammals. When dogs become badly infested the ticks may be removed by washing the dogs with one of the standard tick dips. Ordinarily hand picking will suffice to keep them in check.

THE TROPICAL HORSE TICK.

Dermacentor nitens Neumann.

The common name of this species is derived from the fact that its distribution is restricted almost entirely to the Tropical Life Zone and that the horse is its principal host.

DESCRIPTIVE.

Adult (Pl. XIII, figs. 8–10, 13, 14).—Males 2.5 by 2 mm. to 3 by 2 mm. Females, unengorged, 3.25 by 1.75 mm. to 3.5 by 2 mm.; engorged, 9 by 7 mm. to 12 by 9 by 5 mm. Both sexes are reddish brown and without white markings.

Nymph (Pl. XIII, figs. 7, 11, 12).—Unengorged, about 1.33 by 0.9 mm.; engorged, 2.9 by 1.8 by 1 mm. to 3.5 by 2.2 by 1.3 mm. Color, unengorged, pale brownish yellow; engorged, dark gray. Capitulum, 0.359 mm. long (from tip of hypostome to base of emargination of scutum); scutum 0.54 mm. long by 0.641 mm. wide. The shape of the nymph, particularly when engorged, as with the engorged female, is quite typical of the species; the greatest width is at the third pair of legs, from which the body is very noticeably constricted posteriorly.

Larva (Pl. XIII, fig. 6).—Unengorged (in balsam), 0.714 by 0.470 mm.; engorged, 1.5 by 0.9 by 0.6 mm. Color, unengorged, yellowish brown; engorged, steel-gray. Capitulum 0.205 mm. long (from tip of hypostome to base of emargination of scutum); scutum 0.290 mm. long by 0.372 mm. wide.

Egg.—The average size of 10 eggs measured was 0.565 by 0.419 mm. Color yellowish brown to brown; shining, smooth.

HOST RELATIONSHIP.

The type host of this tick, the horse, is the principal host for the species. This tick has also been taken from the ears of the mule at Brownsville, Tex., and at Tampico and Victoria, Mexico, Bishopp found it commonly in the ears of both the mule and the ass. It prefers the inside of the ears as a place for attachment. Hooker has found a number of specimens attached in the horse's mane between the ears and several to the belly. This, however, was due to the fact that the ears were literally filled with ticks so that there was no place in the ears to which they could attach. In Texas several larvæ have been taken from the ear of a goat. The tick has also been taken from the ears of the ox and of a calf. A single specimen in poor condition, but apparently of this species, was taken at Kerrville, Tex., by Mr. F. C. Pratt from a deer skin that had been removed in January. In our studies we have found them to attach to the scrotum of a bovine and develop to engorged adults.

GEOGRAPHICAL DISTRIBUTION.

(Fig. 17.)

Jamaica and Santo Domingo are the type localities for this species. In the vicinity of Brownsville, Tex., it is an important pest to horses which run in pastures; it has also been taken at Harlingen and at Corpus Christi, Tex. A single specimen which appears to be this species was collected at Kerrville, Tex., but the species has not been found during subsequent collections in that vicinity. There seems to be much doubt of the correctness of the record of this species from Arizona. The tick was found in abundance at Victoria and Tampico, Mexico, but careful search for the species failed to reveal its presence on the plateau in the central and northern parts of that country. It has been recorded from Guatemala, Panama, and Costa Rica in Central America and from Cuba, Jamaica, Haiti, Santo Domingo, and Trinidad in the West Indies. It appears to be a serious pest in Cuba and Jamaica.

LIFE HISTORY.

Observations on the biology of this species have been published by Hooker (1908) and by Newstead (1909).

The egg (Table XCVI).—The first 3 ticks the oviposition of which was recorded were collected from the ears of a horse; the next 7 were picked from the ear of a mule; and the last 2 dropped from the ear of a bovine.

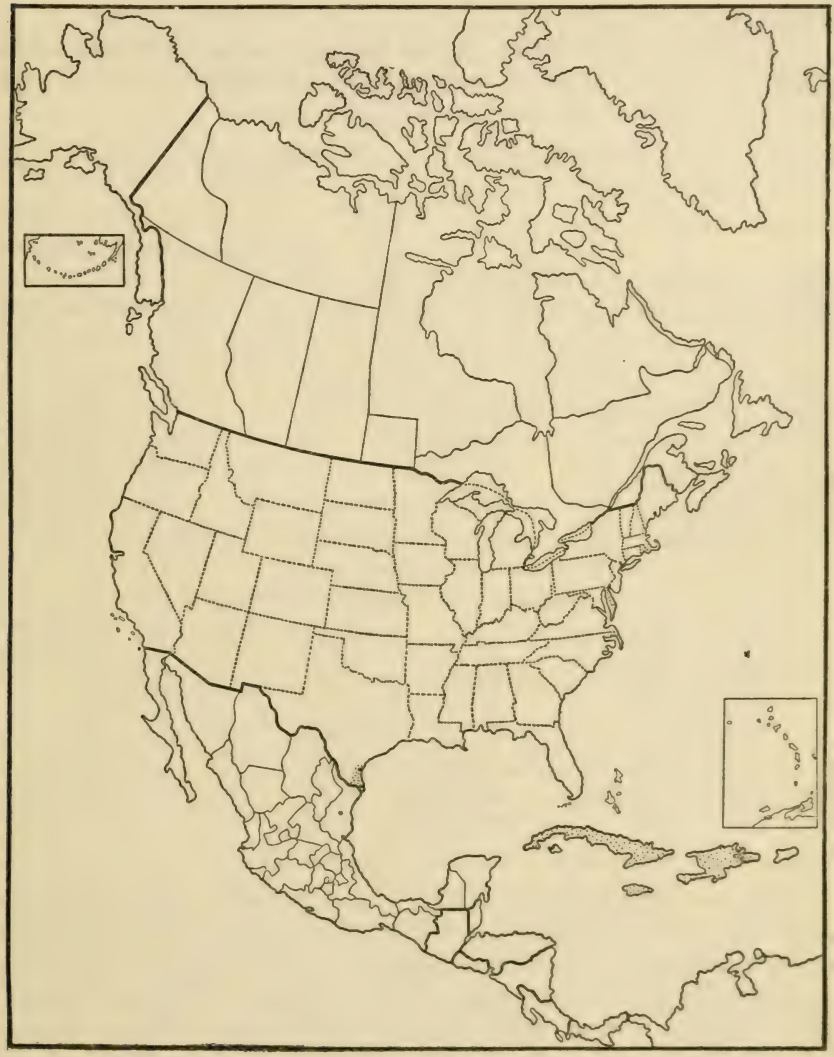


Fig. 17.—The tropical horse tick, *Dermacentor nitens:* Distribution in North America and West Indies. The large dots show localities where the species has been collected in our investigation. The small dots indicate the probable range of the species in North America and the West Indies.

The preoviposition period in the 12 ticks recorded varied from 3 to 15 days. The minimum period occurred in the case of 2 females which dropped from a host on July 27. These ticks were kept at a mean temperature of 85.4° F. The period of deposition ranged from 15 to 37 days. The length of this period, as well as that of the preoviposition period, is materially affected by temperature, the high temperatures producing the shortest periods. The maximum number of eggs deposited by 1 tick was 3,392 in the lot of 12 females observed; the average was 2,784.

The minimum incubation period for eggs in the laboratory at a mean temperature of 85° F. was 24 days. An effective temperature of 935° F. appears to be required for incubation.

TABLE XCVI.—*Preoviposition, incubation, and larval longevity of Dermacentor nitens.*

OUT OF DOORS.

Date engorged female dropped.	Eggs deposited.	Hatching began.	Minimum incubation period.	All larvæ dead.	Larval longevity.	Temperature during incubation.			
						Maximum.	Minimum.	Average daily mean.	Total effective.
1908.	1908.	1908.	*Days.*	1908.	*Days.*	*°F.*	*°F.*	*°F.*	*°F.*
Apr. 22	Apr. 29	June 5	38	Aug. 15	71	91	43	73.2	1,149.2
Do.	...do.	June 6	39	Aug. 7	62	91	43	73.5	1,187.7
May 17	May 21	June 20	31	Aug. 14	55	93	62	79.3	1,125.3
May 18	May 26	June 24	30	Aug. 15	52	96	62	80.4	1,120.6
May 19	...do.	June 26	32	...do.	50	96	62	80.3	1,195
May 20	May 27	June 28	33	Aug. 19	52	96	62	80.3	1,232.5
May 22	May 26	...do.	34	Aug. 28	61	96	62	80.3	1,268.2
May 26	June 2	July 1	30	Aug. 29	59	96	62	80.5	1,124.9

IN THE LABORATORY.

Date engorged female dropped.	Eggs deposited.	Hatching began.	Minimum incubation period.	All larvæ dead.	Larval longevity.	Maximum.	Minimum.	Average daily mean.	Total effective.
	May 2	June 1	31			87	56	75.2	999
	May 3	June 3	32			88	56	75.8	1,049.5
	May 9	June 5	28			88.5	65	77.5	966
	May 10	June 6	28			88.5	65	77.8	957
	May 13	June 8	27			90	65	78.3	952.8
	May 14	June 9	27			90	65	78.7	963.3
	May 15	...do	26			90	67	79	935.3
	July 31	Before Aug. 29	Less than 30	Dec. 5	About 98				
	Aug. 2	...do	Less than 28	Nov. 26	About 89				
	Aug. 6	Aug. 29	24	Nov. 26–Dec. 24	89–117	99	73	85.25	1,014
	Aug. 9	Sept. 1	24	Oct. 26–Nov. 17	55–77	96.5	73	84.4	1,000

The larva (Tables XCVI–XCVII).—As is shown in Table XCVI, the longevity of larvæ which hatched in June and were kept in tubes under the most favorable conditions was only 71 days. All of the larvæ from eggs of females which dropped in May were dead 2 months after hatching. Seed ticks hatching from eggs isolated at daily intervals and kept in tubes in the laboratory were frequently found to die in 10 days or 2 weeks. The greatest longevity of this stage observed by us was between 89 and 117 days. This species, the cattle tick, and another species of Dermacentor (*albipictus*), which is now being studied, are the only species occurring in the United States, which, so far as known, pass both molts upon the host. As a result of this habit great numbers of ticks reach maturity and reproduce, but fortunately there has also resulted a great decrease in the power of the larvæ to withstand periods of fasting.

As is shown in Table XCVII, larvæ may engorge and molt as soon as the eighth day after attaching to a host. The longest period from larval attachment to molting was 16 days.

The nymph (Table XCVII).—In two of the three lots recorded in Table XCVII nymphs became engorged and began molting on the seventeenth day after being applied to the host as larvæ. In the third infestation nymphs began molting to adults on the twenty-fourth day after being applied. The period from the molting of the first larvæ to the molting of the first nymph was 8 days in one instance and 9 days in the other two cases observed. In one instance the nymphal period appeared to have been only 7 days.

The adult (Table XCVII.—The mating of males and females of this species, which molted on the host on the same day, took place as soon as the second day following and was continued until the engorged females dropped. This habit appears to be similar to that of *Margaropus annulatus*. A male *Amblyomma americanum* has been found attached beneath a female of this species, the ventral surfaces being in apposition as though in copulation. The sexes remained in this relation for only a short period. Likewise males of *Margaropus annulatus australis* and *Dermacentor variabilis* have remained mated with females of the tropical horse tick for a number of days. Several females have engorged and dropped, apparently without having been fertilized. One unfertilized female remained attached from the time it molted on May 6 until May 26, when it dropped unengorged. A second unfertilized female which molted July 18 dropped August 11 when only slightly engorged.

Females have engorged as soon as 9 days after molting or 26 days after attachment to the host as larvæ. The longest engorgement period observed was 23 days after molting, or 41 days after being applied to the host as a larva. Females collected at Brownsville, Tex., in November have reattached to a host 3 days later. A slightly engorged female thus transported attached and dropped engorged 7 days later, measuring 10 by 8 by 5 mm. Newly molted females reared from engorged nymphs taken from a horse have attached to a bovine. One thus attached on December 9, 1907, dropped engorged 11 days later, measuring 10 by 7 by 4.5 mm. A second, attached at the same time, dropped after 15 days of attachment, measuring 10.5 by 7.5 by 4.5 mm.

A male has been found to remain upon a host 84 days after the first female dropped, or 99 days after attachment as a larva. At the end of this period it was found dead in the retaining bag. Upon another host a male remained for 72 days after the last female dropped, or 86 days after it had been collected from an equine and placed upon the bovine. It detached and escaped from the bag at the end of this time.

A peculiar habit which is especially noticeable in this species is that of the excretion, by the female during engorgement, of large quantities of a substance which when dry resembles coagulated blood. This habit, while particularly noticeable in the members of the genus Dermacentor, is most pronounced in this species. It is a frequent occurrence for the male to get incrusted in the excreta and, being unable to extricate himself, to perish. It is this habit of voiding large quantities of excrement that increases to some extent the economic importance of this tick.

PARASITIC PERIOD.

The parasitic cycle of three lots was followed upon bovines at the laboratory. Two of these lots were placed upon the scrotum of the host and the third in the ear.

On April 10, 1908, numerous larvæ were placed on the scrotum of a bull; 2 molted to nymphs on April 23, 2 on April 24, and 1 on April 25, or the thirteenth, fourteenth, and fifteenth days, respectively, after application. On May 4, 1 molted to a female; May 6, 1 molted to a female; and May 19, 2 molted to females; or the twenty-fourth, twenty-sixth, and twenty-ninth days after application. As no males were present the females were not fertilized and they only partially engorged. A second lot of larvæ was applied to the scrotum of a bull on April 18, 1908. They began to molt on the ninth day and molted as follows: April 27, 3; April 28, 6; April 29, 2; April 30, 1. On May 5, the seventeenth day after application, 1 nymph molted to a male, and molting continued as follows: May 6, 1 male, 1 female; May 7, 1, and from May 9 to 11, 1 molted each day, and on May 13, 2 molted, the sex of the last mentioned not being recorded. The first engorged female dropped on May 17, or 29 days after attachment as a larva. Others dropped engorged on July 18, 19, and 20; 2 on July 22, and the last on July 26, or 38 days after having attached as a larva.

A third lot of larvæ was applied to the ear of a host on July 1, 1908. They began to molt 8 days later (July 9), many having molted by the ninth day and all by the eleventh. Many nymphs were fully engorged on July 14, but did not molt until the seventeenth day (July 18), when 2 males and 2 females appeared; all had molted by the following day. Three females dropped engorged on July 27, the twenty-sixth day from attachment; a partially engorged female was crushed on July 29 and the last female was missing on August 11, after having remained mated with a male for 10 days.

TABLE XCVII.—*Summary of parasitic periods of Dermacentor nitens on a bovine.*

Date larvæ applied.	Location.	Days following application of larvæ.					
		Larvæ molted.		Nymphs molted.		Females dropped.	
		First.	Last.	First.	Last.	First.	Last.
1908.							
Apr. 10	Scrotum	13	15	24	29	Not fertilized.	
Apr. 18	...do	9	16	17	26	29	38
July 1	Ear	8	11	17	18	26	41

LIFE CYCLE.

The larvæ are short lived, living only 71 days in summer under the most favorable conditions; they engorge and molt on the host as soon as 8 days after attachment. Nymphs may molt as soon as the seventeenth day after attachment or 7 days after the larvæ molt. Adults may engorge and drop as soon as 9 days after the nymphal molt or 26 days after attachment as larvæ. In summer oviposition may commence on the fourth day following dropping and as many as 3,392 eggs may be deposited. Eggs may hatch in 24 days during the summer. An effective temperature of 930° F. appears to be required for incubation.

ECONOMIC IMPORTANCE.

In the United States this tick has been found to be of considerable economic importance in the vicinity of Brownsville, Tex. In November, 1907, one of the authors (Hooker) accompanied by Mr. J. D. Mitchell visited the Carman Ranch, 7 or 8 miles north of Brownsville, where a dozen or more horses had been at pasture for a number of weeks. Several of these animals were lassoed and examined. Their ears were found to be literally filled with ticks of this species in all stages of development. The molted skins and excrement which had collected in the ears in large quantities were the source of a nauseating stench. Bishopp observed similar conditions among horses, mules, and burros at Tampico and Victoria (Tamaulipas), Mexico, during December, 1909, all stages of the tick being present at that time. He was informed that this is a troublesome pest in that region. Work animals become "touchy" about the head and sometimes refuse to be bridled. Several men stated that the ears of animals frequently suppurate extensively and that in some cases the distal half of the ear drops off.

Dr. N. S. Mayo, in the report of the Cuban Experiment Station for 1907, page 25, says: "These ticks sometimes collect in horses' ears in such numbers as to cause the ears to lop and the screw-flies attack the ear and permanently disfigure the animal." The filth and decaying animal matter must frequently result in suppuration and extensive proliferation, as well as forming a suitable place for the breeding of screw-worms.

NATURAL CONTROL.

No natural enemies of this tick have been recorded in the United States. Cold appears to have a decided effect on both adults and larvæ. At Dallas, Tex., during the early winter of 1909, when a minimum temperature of 20° F. was reached, many engorged females were killed and the few eggs deposited by others failed to hatch.

ARTIFICIAL CONTROL.

This tick is undoubtedly the easiest species to deal with that occurs in the United States on account of the short life of the larvæ and the ease with which the ticks may be destroyed on the host. The frequent application of oil to the ears will assist in keeping horses free from them. One of the authors is informed by men at Tampico, Mexico, that kerosene and lard are frequently applied to the ears of horses and mules in that section in order to destroy the ticks. Reinfestation was said to take place again very soon, however, as no effort is made to prevent the dropping of the engorged females or to starve the larvæ. The keeping of stock from an infested pasture for four months in summer will probably be sufficient to insure the starvation of the seed ticks.

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INDEX.

Page.

- Æstivation in *Dermacentor venustus* 35
- *Agelaius phœniceus.* (*See* Blackbird, red-winged.)
- *Amblyomma americanum*, adult, descriptive 142
    - life history 148–150
  - control, artificial 151
    - natural 151
  - descriptive 142
  - distribution, geographical 143–144
    - zonal, in North America 22
  - economic importance 150
  - egg, descriptive 142
    - life history 144–145
  - eggs deposited, number 33
  - host relationship 142–143
  - larva, descriptive 142
    - life history 146
  - life cycle 150
    - history 144–150
  - longevity of stages, maximum 71
  - mating habits 29
    - with female of *Dermacentor nitens* 201
      - females of other species of ticks 149
  - not an agent in the transmission of splenetic fever 123, 150
  - nymph, descriptive 142
    - life history 146–148
  - periods in life history, maximum and minimum 70
  - work on biology in 1899 20
  - *cajennense*, adult, descriptive 151
      - life history 156–157
    - control, artificial 158
      - natural 158
    - descriptive 151–152
    - distribution, geographical 152
      - zonal, in North America 21, 22
    - economic importance 157–158
    - egg, descriptive 152
      - life history 153–154
    - eggs deposited, number 33
    - host relationship 152
    - larva, descriptive 151
      - life history 155
    - life cycle 157
      - history 153–157
    - longevity of stages, maximum 71

Page.
Amblyomma cajennense, nymph, descriptive 151
life history 155–156
periods in life history, maximum and minimum 70
pest to man in Jamaica 152
coronatum, oviposition, first description of process 73
dissimile, adult, descriptive 130
life history 134–135
control, natural 135
descriptive 130–131
dissemination 34
distribution, geographical 131
zonal, in North America 21, 22
economic importance 135
egg, descriptive 131
life history 131–132
eggs deposited, number 33
host relationship 123, 131
larva, descriptive 130–131
life history 132–133
life cycle 135
history 131–135
longevity of stages, maximum 71
nymph, descriptive 130
life history 133–134
periods of life history, maximum and minimum 70
general account 123
goldii, host relationship 123
studies in 1909 123
hebræum, agent in dissemination of heartwater of sheep, goats, and cattle 123
bibliographic reference 209
detachment after death of host 72
eggs deposited, maximum 75
number 32
mating habits 30, 31
studies in 1899 123
maculatum, adult, descriptive 135
life history 139–141
control, artificial 142
natural 141
descriptive 135–136
distribution, geographical 136
zonal, in North America 21, 22
economic importance 141
egg, descriptive 136
life history 137–138
eggs deposited, maximum 75
number 32, 33
female mating with male *Amblyomma americanum* 149
host relationship 136
larva, descriptive 135–136
life history 138–139
life cycle 141

Page.

- *Amblyomma maculatum*, life history, 137–141
    - longevity of stages, maximum, 71
    - males more commonly collected than females, 76
    - nymph, descriptive, 135
        - life history, 139
    - periods in life history, maximum and minimum, 70
    - prairie species, 123
- *marmoreum*, host relationship, 123
    - studies in 1905, 123
- mating habits, 31
- *tuberculatum*, adaptations of habit, 28–29
    - adult, descriptive, 123–124
        - life history, 129
    - attachment to carapace of turtle, 72
    - control, natural, 130
    - descriptive, 123–124
    - distribution, geographical, 124
        - zonal, in North America, 21, 22
    - economic importance, 130
    - egg, descriptive, 124
        - life history, 125–126
    - eggs, deposited, number, 33
    - host relationship, 124
    - hosts, accidental, 25
    - larva, descriptive, 124
        - life history, 126–127
    - life cycle, 129–130
        - history, 125–129
    - longevity of stages, maximum, 71
    - males more commonly collected than females, 76
    - nymph, descriptive, 124
        - life history, 127–128
    - periods in life history, maximum and minimum, 70
    - vesica biloba and its use in oviposition, 73
- *variegatum*, cannibalism, 32
    - dissemination, 34
    - eggs deposited, maximum, 75
        - number, 32
    - studies in 1894–95, 20, 123
        - 1905, 123
- *varium*, largest tick on record, 129
    - studies in 1909, 123
- Anaplasma causing fever in bovines, transmission by Margaropus, 111
    - parasites of ticks, 44
- Ani. (See *Crotophaga ani* and Blackbird, parrot-billed.)
    - groove-billed (see also *Crotophaga sulcirostris*).
        - host of *Hæmaphysalis leporis-palustris*, 90
- Anteater, host of *Amblyomma cajennense*, 152
- Anticoagulin in salivary glands and intestines of *Argas miniatus*, 60
- Ant, little black. (See *Monomorium minimum*.)
- Ants, enemies of *Margaropus annulatus australis*, 122
- *Aponomma inornata*, distribution, zonal, in North America, 22
- Apophyses of mandibles of ticks, definition, 16

Page.

- Argas, adaptations of habit, 28
  - *americanus*, bibliographic reference, 206, 207
  - *brevipes*, distribution, zonal, in North America, 22
    - in United States, 45
    - general account, 45–46
  - *miniatus*, adaptations of habit, 27
    - structure, 26
    - adult, descriptive, 46
      - life history, 58–59
    - agent in transmission of *Spirochæta gallinarum* and *S. anserinum* in fowls, 46
    - bibliographic reference, 208
    - control, artificial, 61
      - natural, 60
    - descriptive, 46–47
    - distribution, geographical, 47
      - zonal, in North America, 21, 22
    - economic importance, 60
    - egg, descriptive, 47
      - life history, 47–53
    - eggs deposited, number, 33
    - habits, 46
    - host relationship, 47
    - larva, descriptive, 46–47
      - life history, 53–55
    - life cycle, 59–60
      - history, 48–59
    - longevity, maximum, 45
    - mating habits, 29–30
    - nymph, descriptive, 46
      - life history, 55–58
    - rearing methods, 39
    - secretions, 31
  - *persicus*, bibliographic references, 207, 208, 212
    - identity, 45, 46
    - mating habits, 30
  - *reflexus*, economic importance, 45–46
    - erroneously reported from United States, 45
    - parasite of fowls, 45–46
  - sp., bibliographic reference, 207
  - *talaje*, bibliographic reference, 208
- Argasidæ, development, 45
- Ass (*see also* Burro and Donkey).
  - host of *Dermacentor nitens*, 198
    - *occidentalis*, 182
    - *variabilis*, 191
    - *venustus*, 166
  - *Ornithodoros megnini*, 62
- Badger, host of *Amblyomma americanum*, 143
  - *Dermacentor variabilis*, 191
    - *venustus*, 166
  - *Ixodes kingi*, 82, 83

Page.

- *Bartramia longicauda*, enemy of ticks 43
- Batrachians, probable enemies of *Hæmaphysalis leporis-palustris* 96
- Bear, brown, host of *Dermacentor venustus* 166
- Beetle, host of *Amblyomma tuberculatum* 136
- Birds, enemies of *Dermacentor variabilis* 197
    - *Hæmaphysalis chordeilis* 102
    - ticks 42–43
  - hosts of Argas 46
    - *Ixodes scapularis* 77
    - *Rhipicephalus sanguineus* 103
- Blackbird, Brewer's (see also *Euphagus cyanocephalus*).
    - host of *Hæmaphysalis leporis-palustris* 90
  - enemy of *Dermacentor venustus* 180
  - parrot-billed (see also *Crotophaga ani*).
    - enemy of *Amblyomma cajennense* 158
  - red-winged, enemy of cattle tick 42
    - host of *Amblyomma tuberculatum* 136
      - *Hæmaphysalis chordeilis* 97
  - savannah. (See *Quiscalus crassirostris.*)
  - species unknown, enemy of ticks 42
- Blackbirds, enemies of *Margaropus annulatus australis* 122
- *Blastocerus dichotomus*, host of *Margaropus annulatus australis* 117
  - *paludosus*=*Blastocerus dichotomus* 117
- Blue bug, colloquial name for *Argas miniatus* 60
  - jay, host of *Hæmaphysalis leporis-palustris* 90
    - *Ixodes scapularis* 77
- *Boophilus annulatus* (see also *Margaropus annulatus* and Tick, cattle).
    - bibliographic reference 214
  - *australis* (see also *Margaropus annulatus australis*).
    - bibliographic reference 205
- Bovine (*see also* Bull, Cattle, and Ox).
  - host of *Amblyomma americanum* 146, 148, 149, 150
      - *cajennense* 155, 156, 157
      - *dissimile* 132, 133, 134
      - *maculatum* 139, 140
      - *tuberculatum* 127, 128
    - *Dermacentor nitens* 199
      - *occidentalis* 181, 185, 186, 188
      - *parumapertus marginatus* 159, 161, 162, 163, 164
      - *variabilis* 194, 195, 196
      - *venustus* 167, 170, 171, 173, 175, 176, 178, 179
    - *Hæmaphysalis chordeilis* 100
      - *leporis-palustris* 93, 94
    - *Ixodes kingi* 86, 87
      - *scapularis* 79, 80
    - *Margaropus annulatus* 112
    - *Ornithodoros megnini* 67
    - *Rhipicephalus sanguineus* 107, 108, 109
- Brushing in control of ticks 44
- *Bufo marinus*, host of *Amblyomma dissimile* 131
- Bull (*see also* Bovine, Cattle, and Ox).
  - host of *Dermacentor nitens* 202

Page.

- Bullfrog, colloquial name for *Bufo marinus* in Jamaica ... 131
- *Buphaga africanus*, damage inflicted on imported domesticated animals in Africa ... 43
  - enemy of ticks in South Africa ... 43
- Burro (*see also* Ass and Donkey).
  - host of *Dermacentor nitens* ... 203
- *Callospermophilus lateralis cinerascens*, host of *Dermacentor venustus* ... 166
- Calomel against spinose ear tick ... 69
- Camel, host of *Rhipicephalus sanguineus* ... 103
- Canary, host of *Argas miniatus* ... 47
- Capitulum of ticks, description ... 16
- Capybara, host of *Amblyomma cajennense* ... 152
- Carbolic acid and sweet oil against spinose ear tick ... 69
- Cat, host of *Amblyomma americanum* ... 143
  - *Dermacentor venustus* ... 166
  - *Hæmaphysalis leporis-palustris* ... 90
  - *Ornithodoros megnini* ... 62
  - *Rhipicephalus sanguineus* ... 103
  - wild, host of *Dermacentor variabilis* ... 191
    - *venustus* ... 166
- Cattle (*see also* Bull, Bovine, and Ox).
  - Brahman, largely resistant to ticks ... 44
  - hosts of *Amblyomma americanum* ... 143
    - *cajennense* ... 157
    - *tuberculatum* ... 124, 130, 136, 141
    - *Dermacentor occidentalis* ... 182
      - *venustus* ... 166
    - *Ixodes scapularis* ... 77, 81
    - *Margaropus annulatus australis* ... 117, 118
    - *Ornithodoros megnini* ... 62
- *Ceratixodes putus*, distribution, zonal, in North America ... 21, 22
  - mating ... 30
  - *signatus*, distribution, zonal, in America ... 21, 22
- *Cervus virginianus*=*Odontocœlus americanus* ... 112
- Chicken, prairie, host of *Hæmaphysalis chordeilis* ... 97
- Chickens (*see also* Fowls and Poultry).
  - enemies of *Dermacentor venustus* ... 180
  - hosts of *Amblyomma americanum* ... 150
    - Argas ... 46
    - *Spirochæta gallinarum* ... 46
- Chipmunk (see also *Eutamias luteiventris* and *Eutamias quadrivittatus umbrinus*).
  - host of *Dermacentor venustus* ... 171
    - *Ixodes kingi* ... 82
- Chloroform and sweet oil against spinose ear tick ... 69
- Chloronaphtholeum against spinose ear tick ... 69
- *Chrysomyia macellaria* (*see also* Screw-worm fly).
  - eggs deposited in wounds made by *Amblyomma maculatum* ... 141
    - ticks ... 19
- *Citellus columbianus*, host of *Dermacentor venustus* ... 166
  - *Ixodes kingi* ... 82
- Cock, chaparral, host of *Amblyomma americanum* ... 143
  - *Hæmaphysalis leporis-palustris* ... 90, 94

Page.
Cold in control of *Dermacentor nitens* 204
ticks 41–42
Corvus ossifragus, enemy of ticks 42
Cottonseed oil against spinose ear tick 69
Cowbird, eastern. (See *Molothrus ater.*)
red-eyed. (See *Tangavius æneus involucratus.*)
Coyote, host of *Amblyomma cajennense* 152
Dermacentor variabilis 191
venustus 166
Creosote against fowl tick 61
Crotophaga ani (*see also* Blackbird, parrot-billed).
bibliographic reference 213
enemy of *Margaropus annulatus australis* 122
ticks 42
sulcirostris (*see also* Ani, groove-billed).
enemy of cattle tick 42
Margaropus annulatus australis 42
Crow, fish. (See *Corvus ossifragus.*)
Cytodites nudus, bibliographic reference 208
Deer (see also *Odocoileus toltecus*).
black-tailed, host of *Ornithodoros megnini* 62
host of *Amblyomma americanum* 143
cajennense 152
tuberculatum 136
Dermacentor nitens 198
occidentalis 181, 182
variabilis 191
Ixodes scapularis 77
Margaropus annulatus australis 118
marsh. (See *Blastocerus dichotomus.*)
Virginia white-tailed. (See *Odontocœlus americanus.*)
Dermacentor albipictus, activity during winter 35
adaptations of habit 26, 29
distribution, zonal, in North America 22
longevity of larvæ 71
molting habits 25, 70, 158
bibliographic reference 213
electus=*Dermacentor variabilis* 20
feeding habits 158–159
general account 158–159
nigrolineatus, distribution, zonal, in North America 22
nitens, adaptations of habit 26, 28
adult, descriptive 197
life history 201–202
control, artificial 204
natural 204
descriptive 197–198
distribution, geographical 198
zonal, in North America 21, 22
economic importance 203–204
egg, descriptive 198
life history 199–200

Page.
Dermacentor nitens, eggs deposited, number 33
    excretion 31
    female mating with male *Amblyomma americanum* 149
    host relationship 198
    larva, descriptive 198
        life history 200–201
    life cycle 203
        history 199–202
    longevity of stages, maximum 71
    mating habits 31
        with other species of ticks 201
    molting habits 25, 70, 158
    nymph, descriptive 197–198
        life history 201
    parasitic period 202–203
    periods in life history, maximum and minimum 70
  occidentalis, adult, descriptive 181
        life history 187–189
    control, artificial 190
        natural 190
    descriptive 181
    distribution, geographical 182
        zonal, in North America 22
    economic importance 189–190
    egg, descriptive 181
        life history 182–184
    eggs deposited, number 33
    host relationship 181–182
    larva, descriptive 181
        life history 184–185
    life cycle 189
        history 182–189
    longevity of stages, maximum 71
    molting habits 158
    name wrongly used for *Dermacentor venustus* 182, 189
        Virginia record of *Amblyomma maculatum* 136
    nymph, descriptive 181
        life history 186–187
    periods in life history, maximum and minimum 70
  parumapertus, distribution, zonal, in North America 22
    marginatus, adaptations of habit 27
        adult, descriptive 159
        control, natural 165
        descriptive 159
        distribution, geographical 160–161
            zonal, in North America 22
        economic importance 165
        egg, descriptive 159
            life history 161
        eggs deposited, number 33
        host of *Hunterellus hookeri* 165
            relationship 25, 159–160

Page.

- *Dermacentor parumapertus marginatus*, larva, descriptive 159
  - life history 161–162
  - life cycle 164–165
    - history 161–164
  - locomotion 34
  - longevity of stages, maximum 71
  - males mating with females of *Dermacentor variabilis* and *Margaropus annulatus* 164
  - molting habits 158
  - nymph, descriptive 159
    - life history 163
  - periods in life history, maximum and minimum 70
- rabbit. (See *Dermacentor parumapertus marginatus*.)
- *variabilis*, adult, descriptive 190
  - life history 195–196
  - control, artificial 197
    - natural 197
  - descriptive 190–191
  - distribution, geographical 191
    - zonal, in North America 22
  - economic importance 197
  - egg, descriptive 191
    - life history 192–193
  - eggs deposited, number 33
  - female mating with male *Dermacentor parumapertus marginatus* 164
  - host relationship 191
  - larva, descriptive 190–191
    - life history 193–194
  - life cycle 196–197
    - history 191–196
  - longevity of stages, maximum 71
  - male mating with female *Dermacentor nitens* 201
  - molting habits 158
  - nymph, descriptive 190
    - life history 194–195
  - periods in life history, maximum and minimum 70
  - rearing methods 37
  - work on biology in 1898 20
- *venustus*, adult, descriptive 165
  - life history 176–179
  - æstivation 35
  - agent in disease transmission 158
    - transmission of Rocky Mountain spotted fever 111, 165, 180
  - cannibalism 32
  - control, artificial 180–181
    - natural 180
  - descriptive 165–166
  - distribution, geographical 168
    - zonal, in North America 22

Page.
Dermacentor venustus, economic importance 180
    egg, descriptive 166
        life history 168–169
    eggs deposited, number 33
    erroneously reported as viviparous 24
    host relationship 166–168
    investigations by Bureau of Entomology, Montana Agricultural Experiment Station, and Bureau of Biological Survey 13, 14
        in 1907–1909 20–21
    larva, descriptive 165–166
        life history 169–171
    life cycle 179–180
        history 168–179
    locomotion 33
    longevity of stages, maximum 71
    mating habits 29
    molting habits 158
    name used in early investigations for *occidentalis* 182, 189
    nymph, descriptive 165
    periods in life history, maximum and minimum 70
    personnel connected with investigation 166–167
Dipping against brown dog tick 111
    Cayenne tick 158
    Gulf Coast tick 142
    Lone Star tick 151
    Pacific Coast tick 190
    Rocky Mountain spotted-fever tick 181
    ticks 44
Dips against American dog tick 197
Dog, accidental host of cattle tick 25
    enemy of *Dermacentor variabilis* 197
    host of *Amblyomma americanum* 143, 147, 148
        cajennense 152
        maculatum 139
        tuberculatum 124, 130, 136
        Dermacentor occidentalis 182
            variabilis 190, 191, 193, 194, 195, 196, 197
            venustus 166
        Ixodes kingi 82, 83, 88
            scapularis 77, 81
        Margaropus annulatus australis 117, 118
        Rhipicephalus sanguineus 43, 102, 103, 108, 109, 110
    prairie, host of *Ixodes kingi* 83
Donkey (*see also* Ass and Burro).
    host of *Amblyomma cajennense* 157
Dromedary, host of *Rhipicephalus sanguineus* 103
Dryness in control of *Dermacentor parumapertus marginatus* 165
    ticks 41–42
Duck, host of *Argas miniatus* 47
Egrets, enemies of ticks 43
Elephant, host of ticks 43
Euphagus cyanocephalus (*see also* Blackbird, Brewer's).

Page.
Euphagus cyanocephalus, enemy of ticks 42
Eutamias luteiventris, host of *Dermacentor venustus* 166
quadrivittatus umbrinus, host of *Dermacentor venustus* 166
Excretions during engorgement by Dermacentor 158–159
nitens 202
Felis hippolestes aztecus, host of *Amblyomma cajennense* 152
Dermacentor variabilis 191
pardalis, host of *Ixodes scapularis* 77
Fever, African coast, of cattle, transmission by five species of Rhipicephalus 102
biliary, of horses, mules, and donkeys, transmission by a species of Rhipicephalus 102
human tick, transmission by *Ornithodoros moubata* 61
Rocky Mountain spotted, transmission by *Dermacentor venustus* 111, 165, 180
splenetic, in bovines, caused by Anaplasma transmitted by Margaropus. 111
Piroplasma transmitted by Margaropus. 111
Filariæ, parasites of ticks 44
Filaria mitchelli, bibliographic reference 213
recondita, bibliographic reference 217
Fish oil against spinose ear tick 69
Fleas, accidental or temporary hosts thereof 25
Fly, screw-worm. (See *Chrysomyia macellaria*.)
Fowls (*see also* Chickens and Poultry).
enemies of *Argas miniatus* 60
ticks 42
hosts of *Spirochæta gallinarum* 46
isolation, against fowl tick 61
spirochetosis 45–46
Fox, host of *Amblyomma americanum* 143
tuberculatum 136
Dermacentor variabilis 191
Rhipicephalus sanguineus 103
Goose, host of Argas 46
miniatus 47
Spirochæta anserinum 46
Goat, host of *Amblyomma americanum* 143
cajennense 152
tuberculatum 136
Dermacentor nitens 198
venustus 166, 167, 178
Margaropus annulatus 112
australis 117
Rhipicephalus sanguineus 103
mountain, host of *Dermacentor venustus* 166
Gopher, pocket. (See *Thomomys clusius ocius* and *Thomomys fuscus*.)
"Gotched" ears in equines, cause 19
indirectly produced by *Amblyomma maculatum* 141
"Gotch" in donkeys indirectly produced by *Amblyomma americanum* 150
Grackle, boat-tailed. (See *Megaquiscalus major*.)
bronzed. (See *Quiscalus quiscula æneus*.)
great-tailed. (See *Megaquiscalus major macrourus* and Jackdaw.)
tinkling. (See *Quiscalus crassirostris*.)
Guinea pig, host of *Amblyomma cajennense* 155, 156
Argas miniatus 47

Page.

Guinea pig, host of *Dermacentor occidentalis* 181, 185, 186, 187
        parumapertus marginatus 159, 162, 163
        venustus 167, 170, 171, 173, 175, 176, 178, 179
    Hæmaphysalis leporis-palustris 99
    Ixodes kingi 83, 86, 87
Hæmaphysalis, adaptations of habit 28
  chordeilis, adult, descriptive 97
          life history 100–101
      bibliographic reference 208
      control, artificial 102
          natural 102
      descriptive 97
      distribution, geographical 98
          zonal, in North America 22
      economic importance 101–102
      egg, life history 98
      host relationship 97
      larva, descriptive 97
          life history 98–99
      life cycle 101
        history 98–101
      longevity of stages, maximum 71
      molting habits 89
      nymph, descriptive 97
          life history 99–100
      parasite of turkeys 89
      periods in life history, maximum and minimum 70
  general account 89
  leachi, agent in transmission of canine piroplasmosis 89, 110
      molting habits 89
  leporis-palustris, adaptations of habit 27
          adult, descriptive 89
              life history 95
          control, natural 96
          descriptive 89–90
          distribution, geographical 90
              zonal, in North America 22
          economic importance 96
          egg, descriptive 90
            life history 90–92
          eggs deposited, maximum 75
              number 33
          host of *Ixodiphagus texanus* 43, 96
            relationship 25, 90
          larva, descriptive 89–90
              life history 92–93
          life cycle 95–96
            history 90–95
          longevity of stages, maximum 71
          molting habits 89
          nymph, descriptive 89
              life history 93–94
          parasite of rabbits 43

Page.

- *Hæmaphysalis leporis-palustris*, periods in life history, maximum and minimum. 70
  - parasite of quail 89
  - *proxima*, molting habits 89
    - studies in 1909 89
  - *punctata*, agent in transmission of bovine piroplasmosis 89
    - bibliographic reference 208, 211
    - molting habits 89
- Hand picking against American dog tick 197
  - bird tick 102
  - black-legged tick 81
  - Cayenne tick 158
  - Gulf Coast tick 142
  - Lone Star tick 151
  - Rocky Mountain spotted-fever tick 181
  - ticks 44
- Hare, host of *Hæmaphysalis leporis-palustris* 90
  - *Rhipicephalus sanguineus* 103
- Haustellum of ticks 16
- Hawk, accidental host of *Amblyomma tuberculatum* 25
  - host of *Amblyomma tuberculatum* 124
  - marsh, host of *Hæmaphysalis chordeilis* 97
- Heartwater of sheep, goats, and cattle, transmission by *Amblyomma hebræum* 123
- Heat in control of *Dermacentor parumapertus marginatus* 165
  - *Ixodes kingi* 88
  - ticks 41–42
- *Heloderma suspectum*, bibliographic reference 213
- Hog, host of *Amblyomma americanum* 143, 150
    - *cajennense* 152
  - *Dermacentor variabilis* 191
    - *venustus* 166
  - *Ornithodoros megnini* 62
- Horse, host of *Amblyomma americanum* 143, 148
    - *cajennense* 152, 157
    - *tuberculatum* 136
  - *Dermacentor nitens* 197, 198, 199, 203, 204
    - *occidentalis* 182
    - *variabilis* 191
    - *venustus* 166
  - *Ixodes scapularis* 77
  - *Margaropus annulatus* 112
    - *australis* 117, 118
  - *Ornithodoros megnini* 62
  - *Rhipicephalus sanguineus* 103
- Humidity. (*See* Rainfall and Dryness.)
- *Hunterellus hookeri*, bibliographic reference 214
  - parasite of *Rhipicephalus sanguineus* 43, 110–111, 165
    - *Dermacentor parumapertus marginatus* 165
  - reared from ticks in Portuguese East Africa 110–111
- *Hyalomma ægyptium*, detachment after death of host 72
  - eggs deposited, number 32
  - molting habits 25
  - *impressum*, host relationship 25–26
  - *venustum*=*Amblyomma variegatum* 20, 32, 34

Page.
Hylocichla guttata nana, enemy of *Dermacentor occidentalis* ... 190
    ticks ... 43
Hypostome of ticks, description ... 16
Iguana, host of *Amblyomma dissimile* ... 131
Inflammation caused by *Amblyomma americanum* ... 150
    Dermacentor occidentalis ... 189
Isolation in control of fowl tick ... 61
Ixodes, adaptations of structure ... 28
    æqualis, distribution, zonal, in North Amercia ... 22
    affinis, wrong determination of *Ixodes scapularis* ... 77
    angustus, distribution, zonal, in North America ... 22
        woodi, distribution, zonal, in North America ... 22
    arcticus, distribution, zonal, in North America ... 22
    banksi, distribution, zonal, in North America ... 22
    brunneus, distribution, zonal, in North America ... 22
    California. (See *Ixodes californicus*.)
    californicus an important species of genus in United States ... 76
        distribution, zonal, in North America ... 22
        mating habits ... 30
    cookei, distribution, zonal, in North America ... 22
        rugosus, distribution, zonal, in North America ... 22
    dentatus, distribution, zonal, in North America ... 22
    diversifossus, distribution, zonal, in North America ... 22
    general account ... 76
    hexagonus, distribution, zonal, in North America ... 22
        mating habits ... 30
    kingi, adult, descriptive ... 82
            life history ... 87–88
        control, natural ... 88
        descriptive ... 82
        distribution, geographical ... 83
            zonal, in North America ... 22
        economic importance ... 88
        egg, descriptive ... 82
            life history ... 83–85
        eggs deposited, number ... 33
        host relationship ... 82–83
        larva, descriptive ... 82
            life history ... 85–86
        life cycle ... 88
            history ... 83–88
        longevity of stages, maximum ... 71
        nymph, descriptive ... 82
            life history ... 86–87
        periods in life history, maximum and minimum ... 70
    marxi, distribution, zonal, in North America ... 22
    oviposition, first description of process ... 73
    pilosus, bibliographic reference ... 210
        mating habits ... 30
        studies on the species ... 76
    pratti, distribution, zonal, in North America ... 22
    reduvius, bibliographic reference ... 211, 214
    ricinus, agent in transmission of bovine piroplasmosis ... 76, 81

Page.

- *Ixodes ricinus*, bibliographic reference 205. 212. 213
    - mating habits 30
    - oviposition, first description of process 73
    - secretions 31
    - studies on the species 20, 76
- *scapularis*, adult, descriptive 76
    - life history 80–81
    - an important species of genus in United States 76
    - control, artificial 81
        - natural 81
    - descriptive 76–77
    - distribution, geographical 77
        - zonal, in North America 22
    - economic importance 81
    - egg, descriptive 77
        - life history 77–78
    - eggs deposited, number 33
    - host relationship 77
    - larva, descriptive 77
        - life history 79
    - life cycle 81
        - history 77–81
    - longevity of stages, maximum 71
    - mating habits 29. 30
    - not to be confounded with *Ixodes ricinus* 20
    - nymph, descriptive 77
        - life history 79–80
    - periods in life history, maximum and minimum 70
    - work on biology 20
- *sculptus*, distribution, zonal, in North America 23
- *texanus*, distribution, zonal, in North America 23
- Ixodidæ, adult 75–76
    - development 69–76
    - egg 73
    - groups based on molting habits 69
    - larva 74
    - longevity 71
    - nymph 74–75
    - parasitic period 71–72
    - preoviposition 73
- *Ixodiphagus texanus*, parasite of *Hæmaphysalis leporis-palustris* 43. 96
- "Jackdaw" (see also *Megaquiscalus major macrourus*).
    - host of *Hæmaphysalis chordeilis* 97
        - *leporis-palustris* 90
- *Kermes galliformis* mistaken for a tick 24
- Kerosene against fowl tick 61
    - spinose ear tick—a dangerous remedy 69
    - and lard against Cayenne tick 157
        - tropical horse tick 204
        - ineffective against bird tick 102
- Killdeer (see also *Oxyechus vociferus*).
    - host of *Hæmaphysalis chordeilis* 97
- Kingbird. (See *Tyrannus tyrannus*.)

Page.
Labium of ticks 16
Lard and kerosene against Cayenne tick 157
  tropical horse tick 204
  ineffective against bird tick 102
Lark, field, host of *Hæmaphysalis leporis-palustris* 90
Laudanum and sweet oil against spinose ear tick 69
Leporidæ, hosts of *Dermacentor parumapertus marginatus* 25
  Hæmaphysalis leporis-palustris 25
Lepus aquaticus, host of *Dermacentor variabilis* 191
  bairdi, host of *Dermacentor venustus* 166
    Hæmaphysalis leporis-palustris 96
  palustris. (See *Sylvilagus palustris*.)
  cuniculus domesticus (*see also* Rabbit).
    host of *Margaropus annulatus australis* 117
Lion, Mexican. (See *Felis hippolestes aztecus*.)
Lizards, enemies of *Margaropus annulatus australis* 122
Magpie, host of *Hæmaphysalis leporis-palustris* 90
Mammals, hosts of Argas 46
Man, accidental host of rabbit flea 25
    Rhipicephalus sanguineus 103
  attachment by *Margaropus annulatus* rare 112
  host of *Amblyomma americanum* 143, 150
      cajennense 152
      tuberculatum 136
    Dermacentor occidentalis 182, 189
      parumapertus marginatus 159
      variabilis 191, 197
    Margaropus annulatus australis 117, 122
      decoloratus 117
    Ornithodoros megnini 62, 69
Mandibles of ticks 16
Mandibular sheaths of ticks 16
Margaropus, adaptations of habits 26
  annulatus (*see also* Tick, cattle, and *Boophilus annulatus*).
    adaptations of habits 28
    adult, descriptive 111
      life history 115–116
    agent in transmission of Piroplasma and Anaplasma, which cause splenetic fever in bovines 111
    bibliographic reference 208
    cannibalism 32
    control, artificial 117
      natural 117
    descriptive 111–112
    distribution, geographical 112
      zonal, in North America 21, 23
    early investigations by Bureau of Entomology 13
    economic importance 117
    egg, descriptive 112
      life history 112–115
    eggs deposited, number 33
    female mating with male *Dermacentor parumapertus marginatus* 164

Page.
Margaropus annulatus, first studies of life history and habits 20
host relationship 112
larva, descriptive 112
life history 115
life cycle 116
history 112–116
longevity of stages, maximum 71
mating habits 31
molting habits 25, 70
nymph, descriptive 111–112
life history 115
oviposition, published descriptions of process 73
periods in life history, maximum and minimum 70
prey of fowls 42
rearing methods 41
australis (see also *Boophilus australis*).
adult, descriptive 117
life history 120–122
agent in transmission of Piroplasma and Anaplasma, which cause splenetic fever in bovines 111
control, artificial 123
natural 122
descriptive 117
distribution, geographical 118
zonal, in North America 23
economic importance 122
egg, descriptive 117
life history 118–119
eggs deposited, number 33
female mating with male *Amblyomma americanum* 149
host relationship 117–118
larva, descriptive 117
life history 119–120
life cycle 122
history 118–122
longevity of stages, maximum 71
male mating with female *Dermacentor nitens* 201
molting habits 70
nymph, descriptive 117
life history 120
periods in life history, maximum and minimum 70
prey of *Crotophaga sulcirostris* 42
studies of the species 20, 21
microplus=*Margaropus annulatus australis*, according to Neumann 118
decoloratus, agent in transmission of *Spirochæta theileri*, which causes disease of cattle in South Africa 111
detachment after death of host 72
early studies 20
in Cape Colony 118

Page.

Margaropus decoloratus, mating habits 30
    - parasite of man 117
    - used by Theiler in experiment on horse 18–19
  - general account 111

Marmot. (See *Marmota flaviventer*.)

Marmota flaviventer, host of *Dermacentor venustus* 166
  - *Ixodes kingi* 82, 83

Meadowlark (see also *Sturnella magna*).
  - host of *Amblyomma tuberculatum* 136, 139
    - *Argas miniatus* 47
    - *Hæmaphysalis chordeilis* 97, 99, 102
      - *leporis-palustris* 90, 96

Megaquiscalus major, enemy of ticks 42
  - *macrourus* (*see also* "Jackdaw").
    - enemy of ticks 42

"Miana bug," colloquial name for *Argas miniatus* in Persia 47

Mice, enemies of *Argas miniatus* 60
    - *Margaropus annulatus australis* 122
  - hosts of *Argas miniatus* 47

Microtus modestus, host of *Dermacentor venustus* 166
  - *nanus canescens*, host of *Dermacentor venustus* 166

Mink, host of *Ixodes kingi* 83

Molothrus ater, enemy of ticks 42

Monomorium minimum, enemy of *Dermacentor venustus* 180

Mopping against black-legged tick 81
  - Cayenne tick 158
  - Gulf Coast tick 142
  - Lone Star tick 151
  - Pacific Coast tick 190

Mouse, gray meadow. (See *Microtus nanus canescens*.)
  - jumping. (See *Zapus princeps*.)
  - large meadow. (See *Microtus modestus*.)
  - white-footed. (See *Peromyscus maniculatus artemisiæ*.)

Mule, host of *Amblyomma americanum* 143
    - *cajennense* 152, 157
  - *Dermacentor nitens* 198, 199, 203, 204
    - *occidentalis* 182
    - *venustus* 166
  - *Margaropus annulatus* 112
  - *Ornithodoros megnini* 62

Neotoma cinerea, host of *Dermacentor venustus* 166

Nighthawk, host of *Hæmaphysalis chordeilis* 97

Ochotona princeps, host of *Dermacentor venustus* 166
  - *Ixodes kingi* 82

Odocoileus toltecus, host of *Amblyomma cajennense* 152

Odontocœlus americanus, host of *Margaropus annulatus* 112

Opossum, host of *Dermacentor variabilis* 191, 195
  - *Ixodes scapularis* 77

Opsicætus personatus=*Reduvius personatus* 42

Ornithodoros, brief account of genus 61
  - *coriaceus*, distribution, zonal, in North America 23
  - *megnini*, adaptations of habit 27, 28
    - adult, descriptive 62

Page.

- *Ornithodoros megnini*, adult, life history ... 66
    - bibliographic reference ... 213
    - control, artificial ... 69
        - natural ... 69
    - descriptive ... 62
    - dissemination ... 34
    - distribution, geographical ... 62–64
        - zonal, in North America ... 23
    - economic importance ... 68–69
    - egg, descriptive ... 62
        - life history ... 64
    - eggs deposited, number ... 33
    - habits ... 45
    - host relationship ... 62
    - larva, descriptive ... 62
        - life history ... 65
    - life cycle ... 68
        - history ... 64–68
    - longevity, maximum ... 45
    - mating habits ... 29, 66
    - molting habits ... 25
    - nymph, descriptive ... 62
        - life history ... 65–66
    - parasitic periods ... 67–68
    - rearing methods ... 39
    - secretions ... 31
    - supposed sexual call ... 66
- *moubata*, agent in transmission of human tick fever ... 61
    - bibliographic reference ... 211, 214
    - habits ... 45
    - mating habits ... 30
- *savignyi*, experiment by Lounsbury ... 60
    - habits ... 45
    - observations on the species ... 21
    - secretions ... 31
    - tapping sound ... 66
    - *cæca*, mating ... 30
- *talaje*, developmental peculiarities ... 24
    - distribution, zonal, in North America ... 23
    - secretions ... 31
- *turicata*, cannibalism ... 32
    - distribution, zonal, in North America ... 23
    - secretions ... 31
- Ostrich, host of *Argas miniatus* ... 47
- Owl, accidental host of *Amblyomma tuberculatum* ... 25
    - host of *Amblyomma tuberculatum* ... 124
- Ox (*see also* Bull, Bovine, and Cattle).
    - host of *Amblyomma cajennense* ... 152
        - *Dermacentor nitens* ... 198
            - *variabilis* ... 191, 196
        - *Ixodes kingi* ... 83
        - *Rhipicephalus sanguineus* ... 103
- Oxpecker. (See *Buphaga africanus*.)

Page.
Oxyechus vociferus, enemy of ticks 43
Palpi of ticks 16
Parasites of ticks 43–44
Peccary, host of *Amblyomma americanum* 143
        cajennense 152
Perodipus richardsoni, host of *Ixodes kingi* 83
Peromyscus maniculatus artemisiæ, host of *Dermacentor venustus* 166
Petroleum, crude, against fowl tick 61
Phrynosoma cornutum, experiments 129
Pigeon, host of Argas 46
Pika. (See *Ochotona princeps*.)
Piroplasma bigeminum, transmission by *Margaropus annulatus australis* 122
    canis, bibliographic reference 206
    causing splenetic fever in bovines, transmission by Margaropus 111
    parasites of ticks 44
    parvum, bibliographic reference 213
    transmission by species of Margaropus 111
Piroplasmosis, bovine, transmission by *Hæmaphysalis punctata* 89
        Ixodes ricinus 20, 76, 81
    canine, transmission by *Hæmaphysalis leachi* 89, 110
        Rhipicephalus sanguineus in old world 102, 110
    ovine, transmission by a species of Rhipicephalus 102
Plover, upland. (See *Bartramia longicauda*.)
Poultry (*see also* Chickens and Fowls).
    hosts of *Argas miniatus* 47
Predaceous enemies of ticks 42–43
Protective adaptations in the genus Dermacentor 158
        of habit in ticks 28–29
Quail, host of *Amblyomma tuberculatum* 136
    Hæmaphysalis chordeilis 97, 102
        leporis-palustris 90, 94, 96
    Ixodes scapularis 77
Quarantine in control of ticks 44
Quiscalus crassirostris, enemy of *Amblyomma cajennense* 157
        Margaropus annulatus australis 122
        ticks 42
    quiscula æneus, enemy of ticks 42
Rabbit, cottontail, host of *Dermacentor parumapertus marginatus* 159
        Hæmaphysalis leporis-palustris 96
    enemy of *Dermacentor parumapertus marginatus* 165
            venustus 180
        Hæmaphysalis leporis-palustris 96
    host of *Amblyomma americanum* 146, 147, 148
            maculatum 139
            tuberculatum 124
        Dermacentor occidentalis 181, 182, 186, 187
            parumapertus marginatus 159, 161, 163, 164, 165
            variabilis 191, 195
            venustus 166, 167, 170, 171, 173, 175, 176, 178, 179
        Hæmaphysalis leporis-palustris 43, 90, 93, 94, 95, 96, 99
        Ixodes kingi 83, 86
        Margaropus annulatus australis 117

Page.

Rabbit, jack, host of *Amblyomma tuberculatum* 136
    Argas miniatus 47
    Dermacentor parumapertus marginatus 159
    Hæmaphysalis leporis-palustris 96
  snowshoe. (See *Lepus bairdi*.)
  swamp. (See *Lepus aquaticus*.)
Raccoon, host of *Dermacentor variabilis* 191
Rainfall in control of ticks 41
Rat, enemy of *Argas miniatus* 60
  host of *Argas miniatus* 47
  kangaroo. (See *Perodipus richardsoni*.)
  wood (see also *Neotoma cinerea*).
    host of *Dermacentor venustus* 171
Rearing ticks, methods 37–41
Reduvius personatus, enemy of ticks 42
Reptiles, hosts of *Rhipicephalus sanguineus* 103
  probable enemies of *Hæmaphysalis leporis-palustris* 96
Rhinoceros bird. (See *Buphaga africanus*.)
  host of ticks 43
Rhipicephalus appendiculatus, mating habits 30
  bursa, adaptations of habit 27
    in West Indies 105
    molting habits 25, 102
  ecinctus, mating 29
  evertsi, adaptations of habit 27
    detachment after death of host 72
    longevity of adults 71
    mating habits 30
    molting habits 25, 102
  general account 102
  sanguineus, adaptations of habit 27
    adult, descriptive 103
      life history 108–110
    agent in transmission of canine piroplasmosis in old world 110
    bibliographic reference 213
    control, artificial 111
      natural 110–111
    descriptive 103
    distribution, geographical 104–105
      zonal, in North America 23
    economic importance 110
    egg, descriptive 103
      life history 105–106
    eggs deposited, number 33
    host of *Hunterellus hookeri* 43, 110–111, 165
      relationship 103
    investigation of life history and habits 21
    larva, descriptive 103
      life history 106–107
    life cycle 110
      history 105–110
    locomotion 34

Page.

Rhipicephalus sanguineus, longevity of stages, maximum 71
    mating habits 31
    molting habits 75
    nymph, descriptive 103
        life history 107–108
    parasite of dogs 43
    periods in life history, maximum and minimum 70
  texanus=*Rhipicephalus sanguineus* 102
Robin, host of *Hæmaphysalis leporis-palustris* 90
Roost, tick-free, construction 61
Rotation (*see also* Starvation).
  system against Pacific Coast tick 190
    ticks 44
    impractical against Cayenne tick 158
      Lone Star tick 151
Sciurus hudsonicus richardsoni, host of *Dermacentor venustus* 166
      Ixodes kingi 82
Screw-worm fly (see also *Chrysomyia macellaria*).
  ovipositing in wounds caused by *Dermacentor nitens* 203, 204
Scutum of ticks, definition 16
Sheep, host of *Amblyomma americanum* 143
      tuberculatum 136, 140
    Dermacentor occidentalis 182
      venustus 166
    Ixodes scapularis 77, 81
    Margaropus annulatus 112
      australis 117, 118
    Ornithodoros megnini 62
    Rhipicephalus sanguineus 103
Skunk, host of *Amblyomma americanum* 143
    Dermacentor variabilis 191
    Ixodes kingi 82, 83
Solenopsis geminata, enemy of ticks 42
Sparrow, host of *Hæmaphysalis leporis-palustris* 90
Sparrows, probable enemies of *Hæmaphysalis leporis-palustris* 96
Spermophile, host of *Ixodes kingi* 83
Spirochæta anserinum, parasite of geese, transmission by *Argas miniatus* 46
  gallinarum, parasite of chickens, transmission by *Argas miniatus* 46
  parasites of ticks 44
  theileri, causing disease of cattle in South Africa, transmission by *Margaropus decoloratus* 111
Spirochetosis of fowls, transmission by *Argas miniatus* 45–46, 60
      reflexus 45–46
Spraying against brown dog tick 111
    ticks 44
Squirrel, fox, host of *Dermacentor parumapertus marginatus* 159, 162
      variabilis 191
      venustus 175, 176
  ground (see also *Citellus columbianus*).
    host of *Dermacentor venustus* 171, 172, 175, 176
  host of *Amblyomma americanum* 143
    Dermacentor variabilis 195
      venustus 173, 175, 176

Page.

Squirrel, pine (see also *Sciurus hudsonicus richardsoni*).
    host of *Dermacentor venustus* 171
        Hæmaphysalis leporis-palustris 90
  rock. (See *Callospermophilus lateralis cinerascens*.)
Starling, enemy of ticks 43
Starvation (*see also* Rotation).
  system against Australian cattle tick 123
    tropical horse tick 204
    impractical against Gulf Coast tick 142
Sturnella magna (*see also* Meadowlark).
  enemy of ticks 43
Swabbing against Rocky Mountain spotted-fever tick 181
Sweet oil and carbolic acid against spinose ear tick 69
    chloroform against spinose ear tick 69
    laudanum against spinose ear tick 69
Sylvilagus nuttalli, host of *Dermacentor venustus* 166
  palustris, host of *Hæmaphysalis leporis-palustris* 90
Tangavius æneus involucratus, enemy of ticks 42
Temperature in control of ticks 41–44
  reckoning in studies of ticks 35–36
Thomomys clusius ocius, host of *Ixodes kingi* 82, 83
  fuscus, host of *Dermacentor venustus* 166
Thrush, dwarf hermit. (See *Hylocichla guttata nana*.)
  host of *Hæmaphysalis leporis-palustris* 90
    Ixodes scapularis 77
Tick, American dog. (See *Dermacentor variabilis*.)
  Australian cattle. (See *Margaropus annulatus australis*.)
  bird. (See *Hæmaphysalis chordeilis*.)
  black-legged. (See *Ixodes scapularis*.)
  brown dog. (See *Rhipicephalus sanguineus*.)
  bull frog. (See *Amblyomma dissimile*.)
  cattle (see also *Margaropus annulatus* and *Boophilus annulatus*).
    annual loss in United States 18
    dissemination 34
    prey of *Agelaius phœniceus* 42
      Crotophaga sulcirostris 42
  Cayenne. (See *Amblyomma cajennense*.)
  fowl. (See *Argas miniatus*.)
  gopher-tortoise. (See *Amblyomma tuberculatum*.)
  Gulf Coast. (See *Amblyomma maculatum*.)
  iguana. (See *Amblyomma dissimile*.)
  Lone Star. (See *Amblyomma americanum*.)
  North American cattle. (See *Margaropus annulatus*, *Boophilus annulatus*, and Tick, cattle.)
  Pacific Coast. (See *Dermacentor occidentalis*.)
  rabbit. (See *Hæmaphysalis leporis-palustris*.)
  Rocky Mountain spotted-fever. (See *Dermacentor venustus*.)
  rotund. (See *Ixodes kingi*.)
  spinose ear. (See *Ornithodoros megnini*.)
  tropical horse. (See *Dermacentor nitens*.)
  wood, colloquial name for *Dermacentor occidentalis* 189
Ticks, adaptations of function 26

Page.
Ticks, adaptations of habit . . . 26–27, 28–29
structure . . . 26, 27–28
bibliography . . . 205–214
biological study, history . . . 20–21
bird enemies . . . 42–43
cannibalism . . . 32
classification . . . 14–17
collecting . . . 17–18
control, artificial . . . 44
by climatic conditions . . . 41–42
parasites . . . 43–44
predaceous enemies . . . 42–43
through immune race of cattle . . . 44
development . . . 24
dissemination . . . 33–34
distribution, geographical . . . 21–23
zonal, in North America . . . 21
economic importance . . . 18–19
excretion . . . 31
fecundation . . . 29–31
habits . . . 25–32
history of biological study . . . 20–21
host relationship . . . 25–26
hosts, accidental or otherwise . . . 25
investigations in Northwestern States by Bureau of Entomology and Montana Agricultural Experiment Station . . . 13–14
Texas by Bureau of Entomology . . . 13, 14
life history, general . . . 24–25
locomotion . . . 33–34
mating habits . . . 29–31
methods employed in studies . . . 35–41
molting habits . . . 24–25
mounting . . . 17–18
multiplication . . . 32–33
parasites . . . 43–44
protozoan . . . 44
periods in life history of economic importance . . . 19
predaceous enemies . . . 42–43
preserving . . . 17–18
protective adaptations of habit . . . 28–29
protozoan parasites . . . 44
rearing methods . . . 37–41
reckoning periods in studies . . . 36–37
temperature in studies . . . 35–36
reproductive capacity of species studied . . . 33
seasonal history . . . 34–35
secretions . . . 31
seed, early information on longevity . . . 20
systematic position . . . 14–17
variation in color and size . . . 16–17
Toad (*Bufo marinus*), host of *Amblyomma dissimile* . . . 131
enemy of *Margaropus annulatus australis* . . . 122
horned. (See *Phrynosoma cornutum.*)

Page.
Toad, host of *Amblyomma cajennense* 152
    dissimile 131
Tortoise, gopher, enemy of *Amblyomma tuberculatum* 130
    host of *Amblyomma tuberculatum* 124
  host of *Amblyomma dissimile* 132, 133, 134
Train oil against spinose ear tick 69
Troglodytes aedon, enemy of ticks 43
Turkey, host of *Hæmaphysalis chordeilis* 97, 101–102
  wild, host of *Amblyomma americanum* 143
    Argas miniatus 47
Tyrannus tyrannus, enemy of ticks 42
Vesica biloba of ticks 73
Water, submergence, in control of *Argas miniatus* 60
Wax in ears of cattle in control of *Ornithodoros megnini* 69
Weasel, host of *Dermacentor variabilis* 191
Wolf, host of *Amblyomma americanum* 143
    tuberculatum 136
  Dermacentor variabilis 191
  Ixodes kingi 83
Woodchuck (see also *Marmota flaviventer*).
  host of *Dermacentor venustus* 166, 175, 176
"Wood tick," colloquial name for *Dermacentor occidentalis* 189
Wren, house. (See *Troglodytes aedon*.)
Zapus princeps, host of *Dermacentor venustus* 166

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